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Child Behavior, Animal Behavior, and Comparative Psychology

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Carl Murchison

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FACTORS IN WHOLE AND PART LEARNING A VISUALLY PERCEIVED MAZE*

From the Department of Psychology, Acadia University, Wolfville, Nova Scotia

THOMAS W. COOK

I. PROBLEM AND PROCEDURE

A recent experiment by Cook, Morrison, and Stacey indicated that for certain conditions of learning a visually perceived maze the part method is superior to the whole method. The present study concerns relations between some of the factors that appeared influential in determining various trends in their data. An ideal follow-up would vary one seemingly significant factor (holding all others constant) in each of several successive experiments. However, as I wished to use subjects trained in the earlier investigation, and the amount of time available made it possible to carry through only one experiment during the balance of the college year, not more than one variable could be studied adequately. The variable selected was *amount of material,* and novel features in procedure were introduced chiefly with a view to determining the influence of this factor on the whole-part problem. In addition, since it appeared to the writer that the effect of one variable would be more evident if the general results showed a clear-cut differentiation between the relative economy of whole and part learning, a number of minor conditions were changed simultaneously in directions that seemed likely to give the maximum advantage to the part method. The present investigation is thus an outgrowth and continuation of the earlier one. The same maze[1] was used in both researches, although of course different patterns were constructed. The outline of procedure which follows accordingly stresses points of difference. Where not otherwise indicated details of method were identical

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[1] Throughout this paper "maze" shall refer (in discussing the present experiment) to the adjustable wooden maze described by Morrison and Cook (3), and "maze pattern" shall signify any specific combination of correct path and blind alleys

1. *Complexity of Maze Pattern.* The maze patterns were of three sizes: *A, B,* and *C,* comprising respectively 12, 24, and 48 "units" of true path. Each pattern contained twice as many culs-de-sac as units of correct pathway, *A,* 24 culs-de-sac; *B,* 48 culs-de-sac; *C,* 96 culs-de-sac.

2. *Equation of Practice, and of Group and Maze Pattern Differences for the Part and Whole Methods, and for Materials of A, B, and C Complexity.* Twelve maze patterns were used, four each of 12 (*A*), 24 (*B*), and 48(*C*) units of true path. These patterns were learned by all subjects in the order *AABBCCCCBBAA.* The 12-unit patterns were thus in positions 1, 2, 11, 12; the 24-unit patterns occupied places 3, 4, 9, 10; and the 48-unit patterns were learned in positions 5, 6, 7, 8. It was expected that since the subjects had considerable practice in maze learning before the present experiment, they would have reached the point of relatively slow descent in the practice curve, and the counterbalanced order would equate the effect of training for the three sizes of maze pattern.[2] To equate individual and maze differences for the part and whole methods and for the *A, B,* and *C* sizes of pattern, and to equalize the effects of practice for part and whole learning, one-half of the subjects (Group I) learned the patterns in the order *PWPWPP-WWPPWWP* (*P* = part, *W* = whole), while the other half of the subjects (Group II) learned the patterns in the order *WPP-WWPPWWPPW.* Thus Group I learned the first of a given pair of patterns (for example, *AA*) of one complexity by the part method and the second pattern of the pair by the whole method, while Group II learned the first of the same pair of patterns by the whole method and the second by the part method.

3 *The Subjects* Eight subjects began work but two were unable to finish, and their results are not included (except in one minor connection) in the data presented. As noted above, the subjects who completed the experiment were divided into two groups, each consisting of one woman and two men. Five of the six subjects had learned four maze patterns in the earlier investigation. The sixth subject had learned two patterns in the same experiment,

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[2] The practice effect from earlier to later maze patterns was greater than had been anticipated, but the important trends are so consistent in direction that this simplifies rather than obscures interpretation.

and in addition had considerable experience in learning other types of mazes.

4. *Starting Point of Maze Patterns.* In the Cook, Morrison, and Stacey experiment it was found that the second of the two halves of each maze pattern was much the more difficult to learn. One factor suggested as a partial explanation of this difference was the lack of definiteness of the starting point of the second as compared with the first half of a given pattern. The latter began at the edge of the maze nearest the subject, the former nearer the middle of the maze. Learning the first part might thus be aided by a more definite orientation relative to the tracing hand and the position of the body To equalize this position factor for the two parts of the maze pattern, and also for the whole as compared with the part method, each pattern in the present experiment began and ended at least five blocks from an edge of the total maze, and the starting point was sometimes nearer, sometimes farther, from the subject than the end of the pattern

5 *Elimination of Retracing Errors.* The use of well-practiced subjects enabled us to introduce a method of preventing retracing errors not feasible in the earlier investigation. An electric bell near the subject's hand was in circuit with a battery and a push-button switch held by the experimenter. As soon as a subject entered a unit of path leading back toward the "earlier" sections of the pattern, the experimenter pressed the button, closing the switch and ringing the bell Each subject, after definite instructions and a period of initial practice on this specific item of procedure, had no difficulty in reversing the direction of hand movement as soon as he heard the bell. Strictly speaking, of course, retracing errors were not entirely deleted, but all possibility of loss of orientation or additional exploration of earlier parts of the pattern (during that trial) *were* avoided, since a subject was stopped by the signal before he went more than one unit in a backward direction.

6 *Emphasis on Errors Rather than Speed* The writer's observations during the conduct of the earlier experiment showed that many subjects who made the poorest records with the part method were trying for speed rather than avoidance of errors; i.e, they went through the maze "as fast as possible" even in the first trial It seemed probable that this was due to a wrong impression of the nature of the maze task, and that subjects would have a more definite

and uniform orientation toward the goal of maze learning if the error criterion were emphasized in the instructions. The typewritten directions accordingly state that avoidance of errors is all-important and speed is not considered. But after a subject had read the instructions he was informed casually that I had decided to record time as well as errors; the latter, however, were of primary importance, and every effort should be made to delete them as rapidly as possible. Whether because of the change in directions or some other factor, the subjects' method of attack on each problem showed great improvement over the earlier experiment. They were alert and confident, with no confusion and little excitement, and, though attending primarily to errors, made very much better time records than in the previous work (Compare Table 2 with Table 4 in the Cook, Morrison, and Stacey paper.)

7. *Criterion of Learning.* Each part or whole maze was considered learned when a subject could trace six successive errorless trials. The unusually exacting standard of learning was adopted to ensure stabilization of each part before attempting to integrate it into a larger whole.

The items of procedure, to the extent that it was deemed advisable for subjects to know them, were embodied in typewritten instructions that follow.

> You are to trace two mazes: one by the part and one by the whole method.
>
> Only errors are recorded. Do not try to hurry. Adopt an even rate of movement and stick to it throughout the experiment Each part or whole maze is considered learned when you can trace *six* trials in immediate succession *without error.*
>
> Retracing errors will be signaled to you by an electric bell. When you hear the bell you are returning to the starting point. Simply *reverse* your direction.

The instructions were read silently by each subject and afterwards explained by the experimenter, and further clarified by a brief period of practice on novel features of the procedure. Otherwise, subjects were in ignorance of the nature and purpose of the experiment. The writer made up the maze patterns before each section of the experiment and recorded the number of errors and the time for each trial during the 15-second interval between that trial and the next. Each maze pattern was learned in a single sitting (massed practice). Two mazes of *A* or *B* complexity were learned in one sitting, one by the part and one by the whole method. A two-minute interval elapsed between the learning of the first and the second pattern Only one maze of *C* complexity was learned in a sitting.

There was also a minor change in the maze. The upper surface of each block was painted dull black. The lighting was kept as uniform as possible without a dark room. The whole experiment covered a period of five weeks.

II. EXPERIMENTAL DATA. COMPARISON OF WHOLE AND PART LEARNING

1 *The First Trial.* Equating the difficulty of Part I and Part II, and the deletion of retracing errors, lead to the discovery that the relative economy of the whole and part methods follows different laws in the first trial and in later trials. For the first trial Table 1 shows that there is no significant advantage in number of errors or speed of tracing for either the part or the whole method The only differences worth considering are for patterns of *A* complexity, and these are in the opposite direction from the results of later trials

TABLE 1

AVERAGE TIME IN SECONDS AND ERRORS FOR THE PART AND WHOLE METHODS IN THE FIRST TRIAL*

	A (12-unit)		*B* (24-unit)		*C* (48-unit)	
Method	Errors	Time	Errors	Time	Errors	Time
Whole	10 6	39.2	22.2	65 7	49 8	149 5
Part	13.3	49 5	22 6	67 1	46 1	152 1

*The values for the part method are the sum of the average errors or average time for Part I and Part II, during the initial learning

Only one conclusion can be drawn from the data in Table 1. The factors conditioning a difference in efficiency of whole and part procedure do not begin to take effect until the end of the first trial. In other words, this difference is a true learning phenomenon which does not appear until the gain from the first tracing is applied in the second trial.

2. *Later Trials.* For (the average of) trials other than the first the superiority of the part method over the whole method is convincingly demonstrated in Table 2. All except two values in

TABLE 2

AVERAGE ERRORS, TIME IN SECONDS, AND TRIALS FOR THE PART AND WHOLE METHODS AFTER THE FIRST TRIAL

	A (12-unit)			*B* (24-unit)			*C* (48-unit)		
	Errors	Time	Trials	Errors	Time	Trials	Errors	Time	Trials
Whole	26.3	94.1	8.9	109	395	20.6	324	1351	31.8
Part	17.1	84.6	12.3	41	230	17.1	192	1139	32.9
Percentage of advantage of part over whole	55%	11%	—38%	166%	72%	20%	68%	19%	— 3%
Difference	9.2			68	165		132	212	
PE_{diff}	5.1			13	42		24.2	121	
Critical ratio	1.8			5.15	3.95		5.5	1.75	

"percentage of advantage of part over whole" are positive. The advantage of the part method is greatest in errors, next in time, and "least" in trials. Indeed, for *A* complexity the trial criterion favors the whole method. However, it should be noted that trials are not on a par with time or errors as measures of economy of learning. A statement of learning efficiency in "number of trials" assumes that the different trials are comparable with one another, and this assumption is certainly not correct as far as earlier and later trials are concerned.

The superiority of the part method is also a function of the size of maze pattern. The part method is most advantageous with patterns of medium (*B*) complexity, next with the largest, or 48-unit (*C*) patterns, and least with the smallest, or 12-unit (*A*) patterns. By the error criterion with *B* complexity the part method shows a striking superiority. The average number of errors is 109 for the whole method and 41 for the part method. When the value for the part method is taken as 100, the corresponding value for the whole method equals 266, an advantage of 166 per cent for the former. The critical ratio ($\frac{D}{P.E_{diff}}$) is the highly satisfactory one of 5.15. Two other critical ratios in Table 2 are sufficiently large to need no outside support: 3.95 for the time measure with complexity *B*, and 5.3 for the error measure with complexity *C*. The critical ratios of 1.8 for errors with the *A* patterns and 1.75 for time with the *C* patterns are large enough to have some intrinsic significance, but are chiefly of importance because of their relationship to trends consistent throughout the data as a whole.

III. Interpretation and Discussion

1. *Differences between the Relative Economy of the Part and Whole Methods in Errors, in Time, and in Trials.* In attempting to account for the fact that the relative superiority of the part over the whole method is greatest in errors, next in time, and least in trials, we need only consider errors and trials, disregarding the "intermediate" time measure. Following the analysis of Cook, Morrison, and Stacey (3), we find the same factors differentiating between the relative economy of the whole and part methods by the "trial" and "error" measures. But the changes in procedure have accentuated

the importance of the first and decreased the importance of the second of their factors.

a. The final (six) trials required to reach the standard of learning each part are included in the total trials for the part method. These trials were of course without effect on the error measure, since they were errorless. Cook, Morrison, and Stacey found that the inclusion or exclusion of the three final trials in initial part learning did not significantly affect their results. However, raising the standard of learning in our investigation to six errorless trials, and the large decrease in the total trials required for learning (due chiefly to the additional practice given the subjects), markedly increase the importance of this factor. Indeed, if we subtract six trials from the totals for the part method, the latter show a superiority over the whole method for trials of 41, 85, and 24 per cent for the *A*, *B*, and *C* complexities respectively.

b. Relatively few errors as compared with trials are made in integrating the parts after they have been learned separately. The percentages of the total effort expended for the part method in combining the parts after separate learning are, with complexity *A*, errors, 35 per cent, trials, 56 per cent; complexity *B*, errors, 14 per cent, trials 42 per cent; complexity *C*, errors, 20 per cent, trials, 36 per cent.

2. *Amount of Material.*

a. Relative difficulty of Part I and Part II. In the experiment by Cook, Morrison, and Stacey more errors were made and more time and trials required for learning Part II than for learning Part I. It seemed probable, however, that the relation of size of maze pattern to the whole-part problem would be clearer if the two parts were equal in difficulty. Table 3 shows that this is the case in

TABLE 3

RELATIVE DIFFICULTY OF PART I AND PART II

Time in seconds

	A (12-unit)			*B* (24-unit)			*C* (48-unit)		
	Errors	Time	Trials	Errors	Time	Trials	Errors	Time	Trials
				First trial					
Part I	7.9	26.2		11.9	31.5		24.6	71.3	
Part II	5.4	23.3		10.7	35.5		21.5	80.7	
				Later trials					
Part I	6.0	14.0	3.0	19.0	66.1	7.7	84.3	371.8	17.2
Part II	5.6	18.0	3.7	16.4	54.5	6.0	72.3	341.2	18.3

the present experiment. The differences between Part I and Part II are small and variable.

It will be remembered that two of the changes introduced into our procedure (as compared with Cook, Morrison, and Stacey) were designed to lessen inequalities between the first and second parts of the patterns. These changes were: equalizing bodily orientation by starting each maze pattern at least five "units" from any edge of the maze, and the preventing of retracing into Part I while attempting to learn Part II. It seems highly probable from theoretical considerations and observation of subjects' behavior that both of these factors contributed to the greater difficulty of Part II in the former experiment, but the part played by each could only be determined by holding one factor constant and varying the other, a refinement of method that the amount of time available and the main purpose of the experiment did not justify.

b. Relation of the whole-part problem to size of maze pattern.

1) *Initial learning.* Cook, Morrison, and Stacey found that one important condition favoring part learning was the greater economy with which a subject learned two "halves" as compared with the "whole" of a given pattern The results of the present experiment are entirely in accord with this conclusion, but the changes in procedure have in some respects sharpened and clarified their distinctions. *In particular, equating Part I and Part II brought to* light another aspect of a trend previously discussed in its bearing of the economy of whole versus part learning: the relation of complexity of material to difficulty is not the same for the first trial as for subsequent trials.

It has been shown (Table 1) that there is no advantage for either part or whole procedure in the first trial. In the three columns on the left of Table 4 the data presented in Table 1 are analyzed to bring out the relation of difficulty of tracing in the first trial to size of maze pattern The first column in Table 4 gives the number of units of maze pattern for complexities *A, B,* and *C,* learned in "halves" or in "wholes." The first number of each pair (e.g., 6 under *A*) refers to the "part" learning. The second column gives *the average errors and average time as in Table 1* *The third column* shows the "errors per unit" and "time per unit," obtained by dividing the number of units of maze pattern (column I) into the average

TABLE 4

RELATION BETWEEN COMPLEXITY AND DIFFICULTY FOR THE FIRST TRIAL AND FOR LATER TRIALS TIME IN SECONDS

Units in pattern	First trial Average errors	First trial Errors per unit	Later trials Average errors	Later trials Errors per unit
	A		*A*	
6	6.65	1.19	5.8	.97
12	10.6	.88	26.3	2.19
	B		*B*	
12	11.3	.94	17.7	1.18
24	22.2	.92	109.0	1.54
	C		*C*	
24	23.1	.96	78.3	3.26
48	49.8	1.04	324.0	6.75
	Average time	Time per unit	Average time	Time per unit
	A		*A*	
6	24.7	4.1	16.0	2.67
12	39.2	3.3	94.1	7.84
	B		*B*	
12	33.5	2.9	60.3	5.02
24	65.7	2.8	395.0	16.46
	C		*C*	
24	76.1	3.2	352.0	11.67
48	149.5	3.1	1350.8	28.14

errors or average time (column II). The latter method of treating the data follows Scott and Henninger,[8] and is designed to reveal any tendency for the difficulty of learning to increase more or less rapidly than the size of maze pattern. If difficulty increases more rapidly than size of pattern the errors per unit or time per unit should show a constant increase. It is apparent that nothing of the sort occurs in the first trial. The number of errors and number of seconds per unit are fairly constant for complexities of pattern from 6 to 48 units, that is, the difficulty of maze tracing in the first trial is directly proportional to the size of the pattern.

The two columns on the right of Table 4, which show a similar treatment of the data for trials subsequent to the first, tell a very different story. For both errors and time the increase in difficulty is much more marked than the increase in size of maze pattern. The most reliable comparisons are between the part and whole learning *for mazes of any given complexity, since these are most accurately* equated for practice and day-to-day variability in individual efficiency, and the same patterns are learned by both part and whole methods. For the *A* patterns the 6-unit parts are learned with an average of 5.8 errors, while the 12-unit wholes show an average of 26.3 errors; that is, doubling the size of maze pattern conditions a 4.5 times increase in difficulty. For the *C* (48-unit) patterns the ratios are about the same: the halves are learned with slightly less than one-quarter of the number of errors made in mastering the whole pattern. With complexity *B* the increase in difficulty is even more disproportionate to the increase in size The 24-unit patterns show about six times as many errors during whole learning as during part (12-unit) learning The column on the extreme right gives the same data in errors per unit. Thus for complexity *A* the errors increase roughly twice as rapidly (.97 to 2.19) as the size of the pattern. The results for time parallel those for errors, except that the increase in difficulty is relatively greater from the parts to the wholes of the *A* patterns.

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[8] These authors (12) give "errors per cul-de-sac" and "time per cul-de-sac." However, as the number of culs-de-sac in our maze patterns is always twice the number of units of true path, our method is essentially identical with theirs

Although the most valid comparisons for different complexities of *maze pattern (within our data) are between the parts and wholes* of the same mazes, it is of interest to consider the interrelations of size and difficulty between the *A, B,* and *C* patterns. Here we *find an interesting discrepancy* Comparing the 12-unit wholes of the *A* patterns with the 12-unit parts of the *B* patterns, and the 24-unit wholes of the *B* patterns with the 24-unit parts of the *C* patterns, we note a decrease in errors per unit and time per unit as we go from the *A* to the *B* or from the *B* to the *C* patterns In each instance the parts of the larger patterns are learned with less expenditure of effort than the wholes of the smaller patterns, though both have the same number of units. The errors per unit are 2 19 for the 12-unit *A* patterns and 1.48 for the 12-unit *B* patterns, 4 54 for the 24-unit *B* patterns and 3.26 for the 24-unit *C* patterns In default of adequate methods of estimating the difficulty of different units of maze pattern any explanation of this trend can be little better than a guess It may mean that I did not succeed in securing comparable patterns or equalizing the practice effects for the *A, B,* and *C* complexities, or may be due to some factor as yet unanalyzed [1]

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[1] One guess would be that subjects were more highly motivated and more confident when told that a given pattern was a "part" rather than a "whole"

The significance of the "law of diminishing returns" for the comparative economy of the part and whole methods is, however, clearly evident in our data Two parts are learned with one-quarter to one-third the errors or time needed in learning the same patterns as a whole Evidently breaking up a complex pattern into more manageable divisions is one of the features of part learning responsible for its relatively high efficiency in visual maze learning The results also suggest that there is a most favorable amount of material for rapid learning, and, conversely, a point in the complexity scale immediately above which the law of diminishing returns operates at a maximum. In the present experiment 12 units is the most economical "part," since learning a 24-unit pattern in 12-unit halves results in a relatively greater gain in efficiency than is obtained by dividing a 12-unit pattern into 6-unit sections or a 48-unit pattern into 24-unit parts This factor is partly responsible for the relatively greater superiority of the part method with the *B* (24-unit) patterns

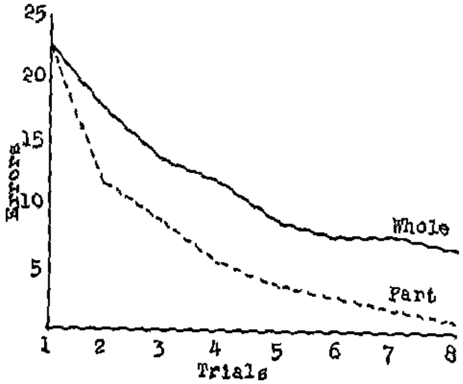

FIGURE 1

Average Errors in the First Eight Trials of Part and Whole Learning *B* (24-Units) Maze Patterns

Figure 1, which gives the average errors for the first eight trials with the *B* (24-unit) mazes, may serve to illustrate the difference between the course of error elimination in part and whole learning In Figure 1 the solid line shows the average errors per trial for the whole pattern, the dotted line the *sum* of the average errors for Part I and Part II of the same mazes The conditions under which the data were obtained thus differ only in that the solid line represents the course of error elimination trial by trial when the mazes are traced as a whole, and the dotted line indicates the course of error deletion when the same patterns are traced in two parts. Since (Table 1 and Table 4) the average errors on the first trial are the same for part and whole learning, the two curves in Figure 1 start from the same point. But in the second trial only two-thirds as many errors are made in part as in whole learning, and the difference between the relative economy of the two methods becomes more marked with each successive trial until in trial 8 the average errors for part learning is 83, approximately one-eighth of the 6.33 errors made in the same trial by the whole method. The course of error deletion for complexities *A* and *C* shows a similar, but slightly less marked differentiation between the two methods[5]

In the present connection it is of interest to note that the percentages of errors made in successive sixths of the trials differ markedly for the 6-, 12-, 24-, and 48-unit maze patterns. These percentages, computed according to the form of the Vincent method outlined by Hunter (6), appear in Table 5 The first trial is of course not included.

TABLE 5

PERCENTAGES OF ERRORS MADE IN SUCCESSIVE SIXTHS OF THE TOTAL TRIALS

Percentage of trials	*A* (12-unit) Part	*A* (12-unit) Whole	*B* (24-unit) Part	*B* (24-unit) Whole	*C* (48-unit) Part	*C* (48-unit) Whole
0- 16.6	26	42	33	42	41	46
16 7- 33.3	21	23	23	23	24	24
33 4- 49.9	15	14	16	14	15	16
50.0- 66.6	14	7	10	11	9	7
66 7- 88.3	12	6	9	5	6	4
88 4-100	12	6	9	5	6	3

In Table 5 the most valid comparison, between the same patterns learned as "halves" or "wholes," 6 with 12-unit in *A*, 12 with 24-unit in *B*, and 24 with 48-unit in *C*, shows that the "parts" are learned in every case with a smaller percentage of errors in the first sixths and a larger percentage of errors in the last sixths of the total trials. Since the trend is consistent throughout, it may be illustrated by a comparison of 12- and 24-unit learning for complexity *B*. Here we find that with 12-unit part learning 33 per cent of the errors are made in the first sixth of the total trials, as against 42 per cent of the errors occuring in the first sixth of 24-unit "whole" learning. On the other hand, 18 per cent of the errors are made in the last third of the trials in 12-unit learning, in contrast with 10 per cent of the total errors found in the final third of the 24-unit learning trials.

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[5] On this account only one graph is presented

However, although it is of interest to discover that the data for visual maze learning do not follow the Kjerstadt-Robinson Law (5), the Vincent method, because it obscures the course of error elimination, is not so satisfactory for our purposes as the trial-by-trial comparison in Figure 1.

The average number of trials needed to attain the ability to trace patterns of a given complexity six times in succession without error was, for the three comparisons of part and whole learning: *A*, 6-unit, 3.4 trials, 12-unit, 8.9 trials; *B*, 12-unit, 6.9 trials, 24-unit, 20.6 trials; *C*, 24-unit, 17.7 trials, 48-unit, 31.8 trials. Just what does this signify regarding the relation between increase in number of trials and increase in complexity? By Scott and Henninger's method of computation, the trials per unit would be .57 for the 6-unit parts and .74 for the 12-unit wholes of the *A* patterns (12). This might be interpreted to mean that the number of trials increases only 30 per cent more rapidly than the size of the pattern. On the other hand, Robinson and Heron's measure of "number of units presented" gives 20 4 for the 6-unit and 106.8 for the 12-unit patterns (11). This seems to indicate that the latter are five times as difficult as the former. Part of the possibility of conflict here arises from the ambiguous nature of the word "trial." When a subject traces each of the 6-unit halves of a 12-unit pattern once, shall we call this one trial or two? In computing the total trials for the part method it is customary to take the whole pattern as a standard, and call each part tracing one-half (or one-quarter, etc) of a trial It seems to the writer that this is the more illuminating approach here, since it makes the trials and errors criteria comparable. Thus the important thing in regard to trials with (for example) complexity *B* is just the fact that subjects need on the average only 6.9 tracings of each of the 12-unit parts, and require 20 6, or about three times as many tracings of *the same patterns* when they are learned in 24-unit "wholes."

2) *Combining the parts after they have been learned separately.* That the relative difficulty of combining the parts after separate learning is, to some extent, also a function of the size of the maze pattern is shown in Table 6, which presents the errors, time, and trials required to integrate the parts, for the *A*, *B*, and *C* patterns. The differences between the *relative* difficulty of combining the parts of the 12-unit (*A*) patterns and the parts of the 24-unit (*B*) patterns are probably not of great significance. The average errors are 5.4 for *A* and 5.7 for *B*, and the translation of these values into errors per unit gives .45 for *A* and .24 for *B*, which seems to indicate a drop in relative difficulty of combining the parts in *B* as compared with *A* patterns. However, the average time of 25.6 seconds for the *A* patterns and 55.6 seconds for the *B* patterns shows about the same average time per unit (2.13 to 2.33) for the 12- and 24-unit patterns, and the number of trials required for combining the parts rises from 3.0 in *A* to 4.25 in *B*. On the other hand, between the 24-unit (*B*) patterns and the 48-unit (*C*) patterns the increase in difficulty of integrating the parts is much greater than the increase in complexity. Six times as many errors are made and five times as much time is needed to combine the *C* patterns. The average errors per unit increase from .24 with *B* to .74 with *C*, and the time per unit from 2.33 seconds with the former to 5.33 seconds with the latter. In addition, 9.2 trials are required for combining two 24-unit parts into a 48-unit whole, but only 4.25 trials for combining two 12-unit parts into a 24-unit whole. Another fragment of evidence in the same connection is that of the 12 attempts at integrating the parts for each size of maze pattern;

TABLE 6

ERRORS, TIME, AND TRIALS FOR COMBINING THE PARTS AFTER SEPARATE LEARNING. TIME IN SECONDS

	A (12-unit)	*B* (24-unit)	*C* (48-unit)
Average errors	5.4	5.7	35.4
Errors per unit	.45	.24	.74
Average time	25.6	55.6	256.0
Time per unit	2.13	2.33	5.33
Average trials	3.0	4.25	9.2

the *A* patterns were combined twice, the *B* patterns five times, and the *C* patterns only once without a single error.

3. *Practice.* While it is impossible wholly to separate the practice factor from the effects of other changes in procedure, it is highly probable that the greater superiority of the part method in the present experiment (as compared with Cook, Morrison, and Stacey) is to some degree due to the additional training given the subjects. However, there is at least one limitation to the principle that part learning is favored by practice. Apparently one aspect of training is improvement in ability to handle larger amounts of material with maximum efficiency, both in initial learning and later integration of the parts into a larger pattern. Cook, Morrison, and Stacey found the 6-unit parts more economical for unpracticed subjects, but some indications that their "practiced" subjects could learn the 12-unit parts most efficiently. In the present experiment with more highly practiced subjects the greater relative economy of the 12-unit parts (*B* patterns) is unequivocal. They are strikingly superior not only to the 6-unit parts (*A* patterns) but to the 24-unit parts (*C* patterns) as well.[6]

The order in which the three sizes of maze pattern were learned (*AABBCCCCBBAA*) makes it possible to study the practice effect from earlier to later "pairs" of patterns of the same complexity, and, since the part and whole methods are equated for practice within each pair of patterns, to see whether practice has any differential effect on the relative efficiency of the part and whole procedures in the earlier and later pairs of the *A*, *B*, and *C* patterns. Table 7 contains data for such a comparison, from which we find that: (1) There is a large practice effect from earlier to later pairs of maze patterns of the same size, for both the part and the whole methods. Moreover, the practice effect is greatest (40.7 to 12.0 average errors in whole learning and 24.5 to 9.7 in part learning) for the *A* patterns, which were learned first and last; next for the *B* patterns, which have only four (*C*) patterns intervening between earlier and later pairs; and least for the pairs of *C* patterns, which were learned

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[6] Thus Cook, Morrison, and Stacey (3) found that with 24-unit patterns the part method by the error criterion showed 21 per cent superiority with unpracticed subjects and 43 per cent superiority with practiced subjects. For like (*B*) patterns my subjects were 166 per cent superior in errors with part procedure.

TABLE 7

COMPARISON OF AVERAGE ERRORS FOR PART AND WHOLE METHODS IN THE FIRST AND LAST TWO PAIRS OF MAZE PATTERNS OF *A*, *B*, AND *C* COMPLEXITY. THE ROMAN NUMERALS INDICATE THE ORDER IN WHICH THE PATTERNS WERE LEARNED*

	A (12-unit)		*B* (24-unit)		*C* (48-unit)	
	V-VI	XV-XVI	VII-VIII	XIII-XIV	IX-X	XI-XII
Whole method	40.7	12.0	138	80	366	282
Part method	24.5	9.7	52	30	220	165
Percentage of advantage of part over whole	65%	24%	165%	167%	66%	77%

*Maze patterns I to IV were used in the experiment by Cook, Morrison, and Stacey (3).

in immediate succession. (2) Practice tends to make the smallest parts less economical and the largest parts more economical. The superiority of the part method declines from 65 to 24 per cent from the first to the second pair of *A* patterns, and increases from 66 to 77 per cent from the earlier to the later learned *C* patterns. The lack of any change in the relative part-whole efficiency for the *B* patterns (165 and 167 per cent) may mean that the 12-unit parts were slightly too large to give maximum economy by the part method with mazes VII and VIII, and slightly too small to give maximum efficiency when the subjects have the additional practice gained before tracing patterns XIII and XIV.

4. *Recency and Retroactive Inhibition.* During the first trial in seven of the 13 attempts at combining the parts of the 48-unit patterns no errors were made in Part II, while a total of 72 (mean, 10.3) occurred in Part I[7] The other six cases include (*a*) Subject *C*, Maze XI, no errors in the act of integration, (*b*) three cases in which the differences in the number of first trial errors between Part I and Part II were negligible (9 to 8, 5 to 3, 1 to 1), (*c*) Subject *G*, whose results do not follow the general trend. In combining the parts of Maze XI, *G* made two errors in the first half and six errors in the second half of the pattern during the first trial. In integrating Maze XI all of *G*'s errors were at the junction

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[7] The errors made in combining the *A* or the *B* patterns were not recorded separately for part I and part II With the *C* patterns the 13 "attempts" include one pattern each by the two subjects who did not complete the experiment, and exclude maze *X* for subject *F*, whose three errors on the first combining trial I failed to note separately for part I and part II.

of the two parts Incidentally, *G* is the only subject who found specific difficulty, with the *C* patterns, in connecting the end of Part I with the beginning of Part II.

Although Part I was learned before Part II, it is extremely unlikely, especially in view of the overlearning from six errorless trials, that the "impression" would suffer any great loss from "fading" during the period elapsing from the learning of Part I and the act of integration a few moments later The great preponderance of errors in Part I during the first attempt at combination is probably due to retroactive inhibition from the interpolated learning of Part II. It is of interest to note also that all subjects except *G* (and, of course, *C* on Maze XI) made many more errors in Part I (367) than in Part II (93), during the trials needed for the *total* act of combining.

5. *Individual Differences.* There are indications in our data that individual differences in ability condition the relative economy of whole versus part learning of a given pattern. The results suggest that these differences are not in the direction of an absolute superiority of whole over part or part over whole learning, but in the size of the "most economical unit" for rapid learning. However, as we have only one sample of a subject's behavior for any given condition of practice, maze pattern, and method of learning, detailed discussion of individual differences between our subjects would be valueless.

IV. THE PRESENT STATUS OF THE WHOLE-PART PROBLEM IN MAZE LEARNING

1. *The Scope and Limits of the Problem.* The work of Cook, Morrison, and Stacey and the present experiment represent the beginnings of a research project designed to test the validity of the writer's "discovery" (from application of the "two-type" theory of learning to the existing experimental data) of a dual pattern of interrelationships between factors conditioning the relative economy of massed and distributed practice (2) This experimental program has not yet been carried far enough to make it advisable to discuss the bearing of the results on basic hypotheses However, as our experiments were planned (in the narrower sense) with a view to finding the causes of certain apparent discrepancies between the data

of earlier workers on the whole-part problem, some attempt will be made to evaluate the relations between our data and their results.

In the subsequent discussion I shall confine myself to experiments on maze learning. Maze learning is usually included as a sub-class under motor learning, and in McGeoch's summary and discussion of the whole-part problem is considered along with the experiments of Barton (1) on typing and Crafts on card-sorting (7). It seems to me, however, that the similarities and differences between maze learning and other forms of "motor" learning are too little understood (especially in view of the paucity of data) to do more than confuse the issue Indeed, it might be argued that psychological processes akin to those involved in maze learning should be looked for rather in rational problem-solving or reading difficult prose than in such a form of motor learning as card-sorting

In considering the work of Barton (1), Hanawalt (5), and Pechstein (10), the only investigators of the whole-part problem using mazes as material, I shall restrict myself to the data for (adult) human subjects,[8] and to the whole versus the "pure part" procedures, since these were the only methods compared in our experiments.

2 *Hanawalt's Criticisms of Pechstein* Some justification may be needed for placing Pechstein's results on a par with those of the other experimenters, since Hanawalt seems inclined to think that Pechstein's data are invalidated by certain supposed defects in his procedure Apart from minor factors such as lack of control of illumination and possible distraction of the subjects by the experimenter's presence, three major "flaws" are indicated

a. The size of Pechstein's maze. "His maze was so small that the whole of it can scarcely be considered a learning problem sufficiently difficult for adequate testing and comparison of methods, and certainly any one of the parts taken separately cannot be so considered" (4, p. 8). This objection is pointless unless one is seeking for an absolute "whole" or "part" method The relation of size of pattern to the whole-part problem is one important aspect of the situation

b. Pechstein's subjects were unpracticed Preliminary training is without doubt desirable, but we have found reason to suspect that (with massed practice) experience may increase rather than decrease the advantage of part procedure.

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[8] Pechstein's and Hanawalt's results are very similar for rats and humans

c. The parts of Pechstein's maze were much alike. Hanawalt considers similarity between the parts undesirable and planned her maze patterns to avoid it. At most, however, the degree of likeness between the successive parts can only be regarded as a difference in method between the two investigations, since Pechstein aimed at a high degree of similarity.

d. Small size of groups. A more serious defect of Pechstein's method (not mentioned by Hanawalt) was the small size of his groups. Groups of six, when only one sample of a subject's behavior is taken, are extremely unlikely to give reliable results. However, we must not overlook the magnitude of the differences that Pechstein found between the efficiency of the part and whole methods under various conditions. Thus the average errors in one set of comparisons were: whole method (returns prevented), massed practice, 204, distributed practice, 81; part ("total part") method, massed practice, 107, distributed practice, 237 (10, p. 77). Differences of this order, even if lacking statistical reliability, make us suspect that some essential factors are emerging.

3. *Evaluation of Factors and Combinations of Factors.*

a. Massed versus distributed repetitions. All the available evidence supports Pechstein's conclusion that massing of repetitions is in general favorable to ("total") part learning, although the present investigation indicates that the amount of this advantage varies with the size of the maze pattern. The three subsequent studies using massed practice, by Barton, Cook, Morrison, and Stacey, and the writer, all find part learning more economical. It is true that Barton's procedure was not wholly "massed." Indeed, McGeoch labels it "distributed." What Barton actually did was to have a constant 15-minute practice period once a day, for both part and whole learning. It is evident that this is neither entirely massed nor entirely distributed procedure. But in my opinion 15 minutes of concentrated learning is sufficient to allow the factors favored by massed repetitions to make a large if not a maximum contribution. A more serious consequence of the fact that Barton had practice periods of equal length for the part and the whole method was that the number of "part" or "whole" trials in a given practice period was necessarily unequal. The number of repetitions in 15 minutes of massed work was much greater with part than with whole learning. On the other hand, in one phase of part learning Barton distributed both time and repetitions Each part was (presumably) learned on a different day, and the act of combining was thus affected by at least a 24-hour interval between the learning of each of the separate parts.

It might be said further that the repetitions in our experiments were not wholly massed, since a 15-second interval elapsed between trials.[9] One must remember, however, that time is not a "cause," but a variable in which effective factors can operate. Whether a *given method is favorably or unfavorably affected by a time interval* depends upon the processes that occur during that interval. Our primary interest has been with the influence of length of time between repetitions upon development or loss of insight. It seemed unlikely (and preliminary tests contra-indicated) that a "just emerging" or newly acquired configuration would be adversely affected by intervals between trials of less than a minute, and highly probable that such novel and unstable insight would suffer from fading or inhibition of the "impression" over long time intervals (as of 24 hours).

Concerning the obverse issue, nothing in the results of other experimenters conflicts with Pechstein's finding that distribution of repetitions favors whole learning, although here, as elsewhere, amount of material and practice are probably important factors. Except Pechstein, who compared the part and whole methods for both massed and distributed procedure, Hanawalt is the only investigator whose procedure I would call distributed Hanawalt's otherwise astounding combination of massing and distribution of repetitions is understandable when we note that her aims included the comparison of rat and human learning (rats cannot learn a complex maze with massed practice), and that she (in common with Barton) thought it more desirable to equate working time than repetitions Hanawalt accordingly gave her subjects two trials a day by the whole method, while for the pure part method the subjects had eight trials a day while learning each quarter, and two trials a day for combining the parts *already* "learned" But, *if my analysis of the factors affecting* the relative economy of massed and distributed repetitions in learning is an approximation to the truth, two trials a day favored the learning of the pattern as a whole, while eight trials a day was a more efficient arrangement for learning each part It is thus probable that Hanawalt would have found even greater advantage for the whole method if the parts had been presented only twice in each experimental session

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[9] A short, probably variable, interval separated the "massed" trials in Barton's experiment (1).

b. Amount of material. The relation of difficulty of learning to size of maze pattern is of sufficient intrinsic interest, apart from its relation to the whole-part problem, to warrant thorough study. The only attempt at a comprehensive investigation has been made by Scott and Henninger (12). Their results indicate that diminishing returns with increasing size of material is at least as evident in maze learning as with nonsense syllables or digits. However, Scott and Henninger's experiment, though a valuable contribution, cannot be regarded as adequate. It should be repeated with larger groups of well-practiced subjects and a greater number of different (especially larger) sizes of maze pattern. Also, it is obvious that complexity of material cannot be considered in isolation. Different relations between learning economy and amount of material may be expected for different conditions of massing and distribution of repetitions, of practice, of type of material, etc. Indeed, our results suggest that the relation between complexity of material and difficulty of learning may change from trial to trial.

Pechstein's and our data agree that with massed practice the transition from simpler to more complex units is accompanied by a very great increase in difficulty. It is of course true that the many differences in procedure between the two investigations render the comparisons suggestive rather than final.[10] There is, however, no conflict between Pechstein's results and our additional findings: (1) the difficulty in the first trial is directly proportional to the size of the pattern, (2) for later trials the increase in difficulty is greatest at some point of transition from simple to complex patterns, the exact location of this transition point depending upon the ability and previous training of the subject.

With distributed practice it is doubtful if returns for effort expended diminish with increasing complexity at the rapid rate that they do in massed practice The only data from maze learning bearing directly on this point come from Pechstein. For human subjects the difficulty of learning the whole as compared with the average for the four parts of his maze was about three times as great for massed as for distributed practice (3, Table 4). It is also possible that part of the advantage of the whole method in Hanawalt's experiment is to be attributed to the large size of her maze patterns, but again interpretation is difficult because of the use of a distribution of two trials a sitting for whole learning and eight trials a sitting for each part—the parts have much greater "massing" of repetitions.

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[10] Barton's data (1) are not given in a form that permits analysis of the rôle of combining the parts as distinct from initial part learning, but his maze was relatively simple and his practice more massed than distributed

A further complication is introduced by the fact that complexity is not an entirely unambiguous concept. There are many kinds of complexity of pattern, and there is no reason to suppose that the difficulty of learning would increase at the same rate with each. For instance, one may complicate a pattern by increasing the number of culs-de-sac at each choice point. In this sense our maze is more complex than that of any of the other investigators, since there were always three alternatives (right, left, and straight ahead) to choose from. Or a maze may be rendered more difficult by increasing the number of units of pathway If a unit of path be defined as the interval between choices, our maze patterns contain a much larger number of units than Barton, Pechstein, or Hanawalt. In the *C* patterns of the present experiment there are 48 choices, each among three possible paths. The nearest approach to this in earlier work is Barton's maze, which had 30 "dual" choices in the total pattern Measured in number of choices or culs-de-sac the mazes used by Hanawalt or Pechstein were relatively simple. Each had 12 alternative paths in the whole pattern, three in each part A third way of increasing complexity of pattern is by introducing more turns and greater variety and length of alleyways in each unit (called by Hanawalt "section") of the true path, or in each cul-de-sac. In this respect our maze patterns are simplicity itself, the interval between choices consisting of only one inch of straight path On the other hand, Barton's and Pechstein's mazes are somewhat, and Hanawalt's enormously, more complicated than ours by the last-named criterion Each section of Hanawalt's patterns from cul-de-sac to cul-de-sac is a little journey in itself.

c. Unity of the whole pattern According to Hanawalt a major element of waste in part learning is loss of unity of the total pattern. In general no exception can be taken to this statement, unless the loss of comprehension of the total task is taken to be a necessary feature of part procedure. One aim of both experiments in which the writer has taken part has been to determine whether it is possible to gain the advantages of part learning without such loss of the larger unity. It is, of course, evident that unless the material contains a pattern that is an integral feature of the whole, such loss shows only during the act of combining the parts. Our instructions that the parts were "halves" of a larger whole, the two-part division, and the use of a maze visible as a whole by the subject throughout the learning process,[11] were specifically designed to avoid waste in integration. That the plan was relatively successful is shown by the small percentage of the total errors (14 per cent in the *B* patterns) made by our subjects in combining the parts.

d. Transfer and interference.

Initial part learning Pechstein states that "neither general nor specific transfer items can be utilized to any high degree in learning a complex motor problem by the whole method," while, on the other hand, "positive transfer items operate at their full value in part learning" (10, p. 54). The main evidence offered in support of this conclusion is that parts II, III, and IV of his maze were mastered with much less effort than was expended in learning part I. What we really need to know, however, is whether there was a like amount of transfer in whole learning. Here Barton's results are in point. The latter computed the percentages of errors and time for each of the four parts of his maze, in both part and whole learning, and found (Table 8) that the "transfer" from first to last parts of his maze pattern was greater, if anything, for the whole method If we can generalize from Barton's data, the part method lost nothing (relative to the whole method) in Hanawalt's experiment by the absence of positive transfer between parts, and no portion of the difference between the latter's findings and those of Pechstein can be attributed to this factor. Our own results show no clear evidence of transfer between parts, and thus apply only indirectly to the problem to the extent that we have been able to isolate other factors that may serve to account for the superiority of the part method in Barton's and one phase of Pechstein's investigation.

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[11] Since all units of the maze surface looked alike such visual orientation could only be of a general nature.

Combining the parts. If we look on the act of integration as an entirely "new" problem, any greater economy relative to whole learning may be attributed to positive transfer from previous experience with the parts. In this sense all experiments except Pechstein's with distributed practice (errors: whole method, returns prevented, 81; combining the parts, 191) show some positive transfer (10, p 77). It would be misleading, however, to single out the group who manifested negative transfer and contrast their results sharply with the data from the other groups The real problem is to discover the factors which condition difficulty in the act of combining, and of these many may be common to the experiments of Pechstein and (for example) Hanawalt. Some such factors have been suggested previously in the discussion of items in our procedure designed to preserve the unity of the total task during the mastery of the separate parts. A further possibility concerns characteristics of the specific maze patterns. Are there any features of a pattern that make its parts more or less difficult to integrate after being learned separately? One guess would be identity of units or relationships between the parts, and in this connection it is significant that experiments on retroactive inhibition indicate that a "medium" degree of similarity gives maximum negative transfer. It would therefore not be unreasonable to suspect that resemblances between parts of their mazes may account for some of the difficulty encountered by Pechstein's and Hanawalt's subjects in the combining act, for although the latter's patterns were avowedly constructed to avoid similarity, the parts are far from being "absolutely" unlike.

I am inclined, however, to believe that ease in combining the parts is more closely related to what I would call "uniqueness of configuration" Anything that heightens such uniqueness of each part simplifies integration, while anything that makes the separate parts more difficult to distinguish as separate parts renders the act of combining more difficult On this hypothesis identity of units would help or hinder or have no effect on integration according to the relation of the units to the total patterns. A right-left "U" choice, for example, might be extremely confusing at the beginning of two maze patterns, but cause no difficulty when located elsewhere in the same patterns, provided the remainder of the patterns were sufficiently unlike to give each a distinct "local sign." From this point of view there are many features of Pechstein's and Hanawalt's procedures that might cause difficulty in the combining act. The parts of Pechstein's patterns were deliberately made so similar that it requires a high level of discrimination to decide which one a learner is tracing at a given time Regarding Hanawalt's maze I can only appeal to the reader's judgment,[12] since quantitative estimates of degrees of similarity between parts of her maze are not only extremely difficult, but out of place until further experiments have been performed For my own part, a survey of the patterns presented by Hanawalt is sufficiently convincing that it would be no easy task to keep the parts distinct. Add to this that the subjects in both experiments had to discover for themselves any shift to a new or return to an old pattern, and that with Hanawalt's apparatus no bodily orientation toward a total pattern was possible, and the difficulties of developing a "unique" configuration of each part become almost insurmountable. On the other hand, Barton's subjects had fixed bodily orientation, and the spatial arrangement of his pattern is such as might give a large measure of uniqueness to the parts. If this is the case the parts of his maze, though "very much alike," should be comparatively easy to integrate Unfortunately Barton does not present data to enable us to decide the question

As we have indicated in discussing "unity of the total pattern," our set-up has many features that minimize confusion between parts On that account the similarity of one part to another, however it might otherwise tend to operate, could cause little difficulty in integration. The sole fragment of direct evidence is the comparatively high percentage of errors in the first as contrasted with the second half of our *C* patterns, which suggests that retroactive inhibition of earlier by later learned parts is responsible for some of the residue of difficulty in combining. The whole field invites experiment.

e. Practice. Hanawalt has pointed out (and our observations are in agreement) that Pechstein's emphasis upon "general transfer items," i e., general maze habit, consciousness of power, and proper emotional attitude, is a result of his use of untrained subjects. That does not mean, of course, that Pechstein's procedure would have been improved by having his subjects undergo an extended period of preliminary practice It would merely have been changed; for the problem of the relative economy of the whole and part methods in the early stages of adaptation to a situation is surely worth investigating. We have found reason to believe, however, that Pechstein's data do not justify his statement that transfer favors part learning, while Barton's study would seem to indicate that the amount of transfer is the same for both methods. There seems, therefore, no basis for concluding that the elimination of "general transfer items" by practice favors either part or whole procedure

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[12] The diagrams appear on page 13 of Hanawalt's monograph (*6*) Hanawalt states (7, p 707) that "each part of the maze was unique in character," but the "uniqueness" must have been rather non-specific, since in combining there was "no recognition by any subject of the fact that the large maze being learned was composed of smaller units already mastered" (7, p 694).

In any case, the part method shows a great superiority with highly practiced subjects in our experiment We have found, however, that practice affects the relative economy of whole and part learning indirectly by increasing the size of the "most favorable unit" for rapid learning With increasing experience the smaller parts become relatively less and the larger parts relatively more efficient "units." That is, practice increases the efficiency of the part method with larger maze patterns and decreases its efficiency with smaller patterns.

SUMMARY

The comparative economy of whole and part learning was tested for six "experienced" subjects with visual maze patterns containing 12, 24, and 48 units or "choice points." A two-part division was used in part procedure Practice was massed and returns prevented. The results follow in outline.

1. *First Trial* The number of errors and amount of time in the first trial were directly proportional to the size of the pattern, whether learned in "parts" or as a "whole." The errors averaged one per choice point

2. *Trials Subsequent to the First.*

a The part method was in general markedly superior to the whole method.

b. The advantage of the part method was greatest in errors, less in time, and least in trials. The comparative inferiority of the part method by the trial criterion is attributed to (1) the inclusion of the final six "errorless" trials from initial part learning, in the total trials for the part method, (2) the relatively large number of trials (as compared with errors per trial) required for integrating the parts after separate learning. The same factors affect the time measure to a less degree

c. Diminishing returns with increasing amount of material was one important factor of advantage in part learning The two parts of the 12-, 24-, and 48-unit patterns were learned with one-third to one-half the expenditure of effort necessary for learning the same patterns as a whole

d. The relative economy of part and whole procedure was to some extent a function of the size of the "whole" maze pattern. Part learning was most efficient with the 24-unit patterns, and about equally economical for the 12-unit and 48-unit patterns The data indicate that in this respect the major difference between the 12-unit and 24-unit patterns was in initial part learning, but that the greater superiority of the part method for the 24-unit as compared with the 48-unit patterns holds equally for primary learning and later combining of the parts.

e Practice increases the amount of material that can be learned with the greatest relative economy. This is suggested by a comparison of the data from Cook, Morrison, and Stacey and the results of the present experiment, and further substantiated by the fact that the 6-unit "parts" are relatively less and the 24-unit parts relatively more efficient in the second (as contrasted with the first) half of the investigation.

f. The Kjerstadt-Robinson Law does not hold for visual maze learning.

g The relatively small difficulty found in integrating the parts shows that comprehension of the total task (usually considered a marked advantage of whole procedure) can be economically obtained during part learning. The ease of integration may be due to · (1) the two-part division, (2) the use of vision while learning, (3) the detailed and specific instructions given the subjects, (4) the high standard set for initial learning.

h For the 48-unit patterns, a portion of the waste in the act of combination was due to retroactive inhibition of part I by the interpolated learning of part II.

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LES FACTEURS DANS L'APPRENTISSAGE GLOBAL ET PARTIEL D'UN LABYRINTHE APPERÇU VISUELLEMENT

(Resumé)

Une investigation par Cook, Morrison, et Stacey a été prolongée dans le but d'étudier l'effet de varier la grandeur des formes de labyrinthe de 12, de 24, et de 48 unités sur l'économie relative de l'apprentissage partiel et global Six sujets entraînes dans l'experience antérieure ont appris 12 formes de labyrinthe On a empêché les retracements et l'on a appuyé sur l'effacement des erreurs, autrement les conditions essentielles suivent l'expérience antérieure Les résultats montrent que la méthode partielle est très supérieure à la methode globale à l'égard des erreurs, moins à l'égard du temps, mais avec très peu de supériorité à l'egard des epreuves pour les deux méthodes. La méthode partielle est la plus avantageuse avec les formes de 24 unités Les différences sont statistiquement de valeur pour les erreurs et le temps avec les formes de 24 unités, et pour les erreurs avec

les formes de 48 unités, et les tendances sont constantes pour toutes les données. L'exercice augmente l'économie relative des parties de 12 unités et de 24 unités comparées aux parties de 6 unités. Le principal facteur qui favorise l'apprentissage partiel, ce sont les résultats diminuants avec la grandeur accroissante de la forme, mais la plus grande supériorité relative de la méthode partielle aux resultats antérieurs est due principalement aux techniques (telle que l'emploi de la vision) qui éliminent la perte dans l'acte de combiner.

COOK

DIE FAKTOREN BEIM GANZ- UND TEILLERNEN EINES VISUELL WAHRGENOMMENEN LABYRINTHS

(Referat)

Eine Untersuchung von Cook, Morrison, und Stacey wurde weiter gefuhrt, um die Wirkung einer Veranderung der Grosse der Labyrinthmuster mit 12, 24, und 48 Einheiten auf die relative Ökonomie des Ganz- und Teillernens zu erforschen. Sechs Vpn., die an einem fruheren Experiment teilgenommen haben, lernten 12 Labyrinthmuster. Die Ruckkehr wurde gehindert und die Ausschaltung von Irrtumern betont, sonst folgen die Hauptbedingungen denjenigen des fruheren Experiments Die Ergebnisse beweisen, dass die Teilmethode der Ganzmethode an Irrtumern merklich uberlegen ist und weniger Zeit braucht, aber wenig Vorteil an Proben bei jeder Methode besitzt. Die Teilmethode ist am gunstigsten bei den 24-Einheitenmustern Die Unterschiede sind statistisch zuverlässig fur Irrtumer und Zeit mit den 24-Einheitenmustern Die Irrtumer mit den 48-Einheitenmustern und die Neigungen sind durchaus ubereinstimmend Übung vermehrt die relative Ökonomie der 12-Einheitenteile und 24-Einheitenteile im Vergleich mit den 6-Einheitenteilen Der Hauptfaktor, der das Teillernen begünstigt, ist die abnehmenden Ruckkünfte bei zunehmender Grosse des Musters, aber die grossere relative Überlegenheit der Teilmethode über die fruheren Ergebnisse ist zum grossen Teil die Folge der Methode (wie die Anwendung des Gesichts), die den Verlust im Akt der Verbindung ausschaltet.

COOK

FUNCTIONS OF THE SUPERIOR COLLICULI IN VISION*[1]

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JOHN D. LAYMAN

INTRODUCTION

Normal vision is the functioning of an intricate mechanism of nervous structures. Analysis of the functions of the various structures, in the different aspects of visual activity, constitutes one of the major problems in the neurology of vision. The development of rapid methods (Lashley, 3) for studying the various visual functions in the rat makes it possible to attack the problem of central visual mechanisms with much hope of success.

Lashley (4) has shown that pattern vision depends upon the intactness of the lateral portions of visual field *w* (Fortuyn's terminology). After destruction of this area he found that the formation of habits involving the discrimination of patterns is lost and cannot be regained by any amount of training

This same experimenter has shown (1) that discrimination of light from darkness is localized in the area striata of the cortex, for with complete destruction of this area in his rats the habit was lost However, he found that the habit could be regained in these animals with occipital lesions by giving them as much training as was required for the initial learning He further found that no other cortical area functioned for the occipital regions in this habit, for rats with the occipital third of the cortex removed learned the problem and did not lose the ability to discriminate when a second operation removed any other third of the cortex

The above facts lead to the conjecture that some subcortical structure is concerned in the functioning of this light-darkness habit,

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[1] The writer wishes to acknowledge his appreciation to Dr K. S. Lashley for his assistance in this project. Some of the data in this article were presented as a part of a master's requirement at the University of Chicago, 1931

But the knowledge that we have of the part played by different subcortical nuclei in vision is quite meager.

A study by Papez and Freeman (9) of subcortical areas points to retardation in the formation of the light-darkness habit in their operated animals, and to the fact that this retardation in point of trials required and errors made is in direct proportion to the extent of lesions in the region of the superior colliculi.

Lashley (2) reported that rats with lesions in the superior colliculi formed the light-darkness habit in the normal manner. He also reported that animals with lesions in the optic radiations learned to choose the illuminated alleyway as rapidly as normal animals In 1931 (4), in other cases with lesions in the superior colliculi, he failed to obtain evidence of vision for objects on the jumping stand. Recently (7), in an attempt to produce entire destruction of the striate area of the cortex he also produced severe lesions in the optic thalami and in the superior colliculi of some of his animals. In those animals with the cortical visual area destroyed plus severe injury to the optic thalamus on one side he obtained a marked retardation in learning to discriminate in the light-darkness box. In others, with severe bilateral destructions in the thalami plus destruction of the cortical areas, learning never occurred.

The fact that on the one hand the light-darkness habit is localized in the cortex, and on the other that it can be formed normally in the absence of this same area, gives rise to the inquiry concerning formation of the habit when the visual cortex is present but when lesions have been made in one or other or all of the subcortical areas concerned in vision This was partially achieved by Papez and Freeman. By using a different procedure than that of Papez and Freeman, the following experiment was undertaken to determine the influence of lesions in the superior colliculi of rats upon the discrimination of light from darkness and upon various phases of pattern vision, with the cortex essential for detail vision left intact.

APPARATUS

A Yerkes' light-darkness box of the usual form was employed in one phase of the study The animals were trained to react positively to the lighted compartment for food, whereas a venture into the darkened compartment resulted in a shock.

A jumping apparatus was also utilized, for Lashley (4) has reported that animals with destructions in the superior colliculi could not be trained to jump, and behaved on the jumping platform as animals blinded by enucleation of their eyeballs In this experiment, only four kinds of stimulus cards were used for the jumping tests One was entirely black and was to be used as a negative stimulus to a black card with a two-inch white square pasted at its center. The other two cards were identical, each having two white strips, two centimeters wide, pasted three-quarters of an inch apart and extending across the width of the card. In the test for pattern vision, one of these (negative) was placed so that the white strips were vertical, the other (positive) was placed so that the strips were horizontal

PROCEDURE

All the animals utilized were operated upon before any training was given The incisions were made through two trephine openings near the mid-line in the occipital region. Through each of these a fine knife was passed diagonally through the longitudinal fissure and into the superior colliculus of the opposite side. The cortex under these trephine holes was frequently cut through, but the area essential for pattern vision was not invaded in the operation

Following recovery from the operation, training commenced. For the first group of rats which were run, preliminary jumping tests were given, and those (4, 5, 11, and 16) which jumped readily were not trained in the discrimination box but were taken directly through the jumping tests, which consisted in discriminating between the black and white card and between the vertical and horizontal striae. All other animals were started in the discrimination box and were later put through the two jumping tests after they had successfully completed the light-darkness problem The criterion of success for the discrimination box was set at 30 consecutive errorless trials and that for the jumping tests was set at 20 consecutive errorless attempts. After training had been completed the animals were killed, their brains fixed, mounted in celloidin, sectioned and stained with iron hematoxylin. Camera lucida drawings and histological examinations were then made and from these the lesions were reconstructed These reconstructed lesions are found in Figure I. Draw-

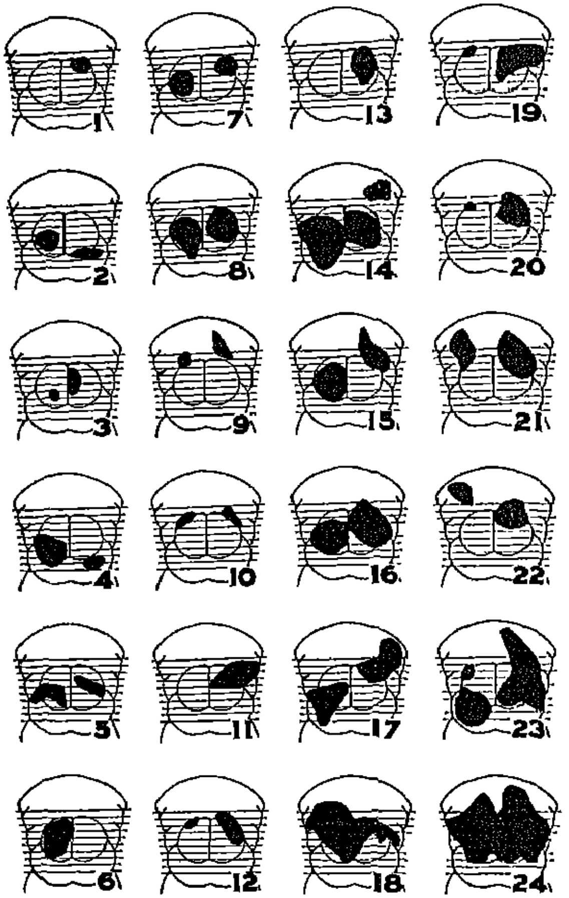

FIGURE 1

ings of typical cross sections through the lesions are found in Figures 2 and 3

Areas Concerned with Vision

This experiment was outlined to determine the function of the superior colliculi in vision, but in performing the lesions localized destructions in this mass were not achieved in many cases Linear knife cuts and degenerative changes were found to have included

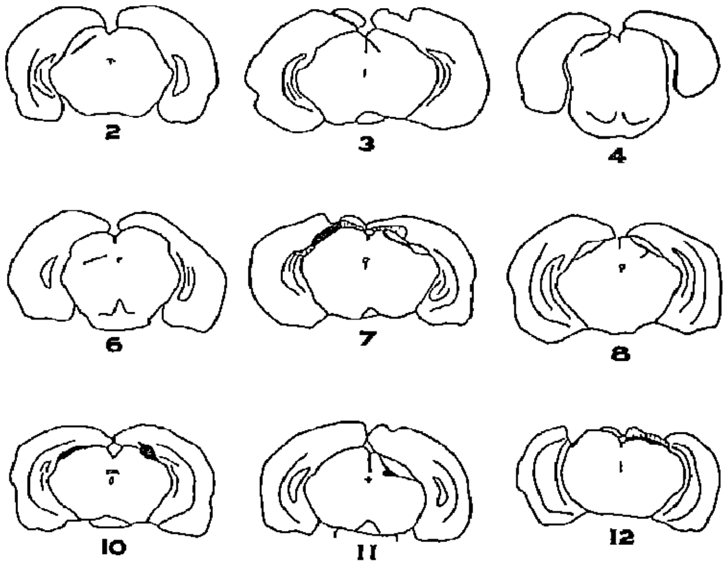

FIGURE 2

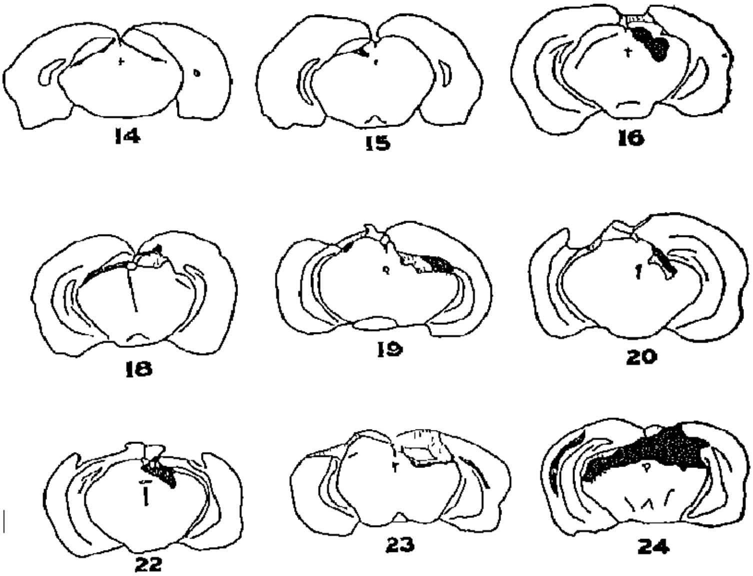

FIGURE 3

one or more basic structures in many animals, and some of these were visual centers

From various anatomical studies (Lashley, 5, 6), several basic nuclei are known to receive fibers from the optic tract. Ventral to the lateral geniculate body the tract gives off its first fibers which go to two hypothalamic nuclei The remainder of the tract proceeds dorsally to the lateral geniculate nucleus where many fibers terminate, but many are found to pass through this nucleus into the more mesial thalamic structures Others are found to pass over the surface of the lateral geniculate body and are seen to dip either into the thalamus between the superior colliculus and the lateral geniculate body, or into the layers of the superior colliculus itself.

Besides the crossed fibers of the chiasma which reach each superior colliculus in this manner, others are believed to ascend to the colliculus from the optic tract after first passing through the lateral geniculate nucleus and the thalamic centers.

The thalamic structures usually conceded to be primary visual centers are the posterior nucleus of the thalamus and the posterior part of the lateral thalamic nucleus. Some authors include a third area which they call the pretectal nucleus. Because of overlapping of lesions in these various structures they shall all three be included under the common head of optic thalamus in the following paragraphs.

Besides the basic nuclei concerned in vision, the cortical areas associated with visual function have been designated by Fortuyn as areas *aa*, *m'*, *and w*. [For explanation see Lashley (2, page 50)]

Experimental Data

Five normal animals were started in the Yerkes' box together with the operated animals and carried through the same tests Six other normal animals were trained only in the light-darkness discrimination and on the black-white jumping problem. The records of these normal animals are presented in Table 1.

Twenty-four animals with lesions in the superior colliculi were given training. The records of these animals are given in Table 2. The arrangement of cases in this table is based upon the number of areas involved, rather than upon trials required in any one problem or upon any particular type of lesion

TABLE 1

Summary of Training Records of the Animals on the Three Problems

Tr = Trials Er = Errors

No.	Yerkes' box Tr.	Yerkes' box Er	Black vs white Tr.	Black vs white Er	2-cm striae Tr	2-cm striae Er
1	97	21	6	3	52	23
2	153	49	23	3	41	14
3	202	54	29	5	57	20
4	146	50	0	0	84	38
5	101	34	25	7	33	9
6	159	55	8	3		
7	171	53	16	5		
8	94	19	0	0		
9	180	65	0	0		
10	109	41	20	5		
11	98	33	19	2		

TABLE 2

Summary of the Training Records of All the Operated Animals for the Three Problems

Tr = Trials, Er = Errors F = Failed to give evidence of discrimination in the trials attempted

No	Yerkes' box Tr	Yerkes' box Er	Black vs white Tr	Black vs white Er	2-cm striae Tr	2-cm striae Er.
1	133	37	Died		—	—
2	180	85	14	6	0	0
3	47	15	180F	99F	—	—
4	—	—	17	12	9	2
5	—	—	44	12	54	20
6	77	22	0	0	136	62
7	168	58	11	1	110F	52F
8	174	26	59	18	40	10
9	104	31	315	128	Died	
10	70	13	219	70	217	62
11	—	—	72	22	37	3
12	220	93	139	29	84	31
13	179	57	44	9	250	92
14	110	24	8	3	Died	
15	214	62	96	33	82	28
16	—	—	142	57	24	4
17	137	48	57	12	8	4
18	119	36	—	—	—	—
19	179	47	5	3	—	—
20	158	53	—	—	—	—
21	313	120	—	—	—	—
22	307	103	—	—	—	—
23	279	80	—	—	—	—
24	900F	357F	—	—	—	—

Four animals (4, 5, 11, and 16) were not trained on the light-darkness problem because they were in the first group to be run, and, as they readily jumped, this part of their training was eliminated. Animals 1, 9, and 14 died before completing the tests, 3 and 24 were killed when they failed to learn the discrimination they were attempting, 18, 20, 21, and 23 would not jump, 19 became unfit to continue training, and animal 22 made only a few jumps at the required distance.

Cases with Lesions Confined to the Superior Colliculi

The first eight animals of Table 2 had lesions confined entirely to the superior colliculi. Of these, the optic tract was injured in animal 8. Because of this injury, this animal will be considered in another section and only the first seven examined here.

Table 3 is a comparative analysis of the trials required and errors made by these seven animals and by the control group on the three problems (Although the table is presented it is realized that little significance can be attached to any statistics employing so small a population.) This table shows that there was only a small group difference between the control and operated groups, not only in the discrimination of light from darkness, but also in the pattern tests. It further shows that this small difference was in favor of the operated animals. On the other hand the table shows that there was some difference in the black-white discrimination on the jumping stand, which was in favor of the controls Although this difference on the first jumping problem was large as measured by the increase in trials required and errors made, it was not reliable.

TABLE 3

Comparative Summary of the Training Records of the Control Animals and of Those With Lesions Confined to the Superior Colliculus on the Three Problems

Tr. = Trials. Er. = Errors

	Yerkes' box		Black vs white		2-cm striae	
	Tr	Er.	Tr.	Er.	Tr.	Er.
Controls	137.2 ± 7.5	43.1 ± 2.9	13.2 ± 2.1	3.0 ± 0.5	53.4 ± 5.3	20.8 ± 3.0
Operated	121.0 ± 15.7	43.4 ± 7.7	19.2 ± 4.5	6.1 ± 1.5	49.7 ± 16.8	21.0 ± 8.4
Difference	16.2	0.3	6.0	3.1	3.7	0.2

The retardation in trials required and errors made in the discrimination of black from white was not a consistent condition among the animals of this first group which jumped Table 2 shows that only two of this group of seven animals were abnormal. Of these, No 3 failed. The failure of this case was perhaps due to a reluctance to jump, for three weeks of urging were required before the animal would attempt the required leap of 25 centimeters. No. 5 was the other retarded animal In this case neither the depth nor the locus of lesion could account for the retardation, for the lesions were no larger nor deeper than in those animals which behaved normally

Table 3 indicates that in all three problems the variability of these animals was at least twice as great as that for the controls Owing to the small number of cases in this section, we are unwarranted in ascribing this variability to any one particular cause.

Animal No 7 failed on the pattern test. Its failure on this problem cannot be ascribed to the cerebral lesion because the geniculostriate system was intact

In summary of the behavior of these seven animals we see that small lesions in one or both superior colliculi do not prevent an animal from discriminating light from darkness, black from white, or horizontal from vertical striae. Confirmation of these results on the light-darkness problem is found in the records of those animals of Papez and Freeman (10) which had lesions confined entirely to the superior colliculi (cases 1, 2, 3, 4, and 6 of group *A*).

CASES WITH LESIONS INVOLVING THE SUPERIOR COLLICULI AND OTHER VISUAL CENTERS

The superior colliculi were partially destroyed or undercut in all animals In cases 8-24 the optic tract was injured or lesions occurred in other visual areas in addition to the superior colliculi. Table 4 is a summary of the lesions found in these animals in the areas concerned with vision

1 *The Light-Darkness Problem.* In Nos 8, 14, and 18 the colliculi were over three-fourths undercut or destroyed, yet, in these cases, learning of the light-darkness problem was normal On the other hand the collicular lesions in cases 21, 22, and 23 were smaller than those in Nos 8, 14, and 16 and these animals were retarded on the problem. Although other structures were invaded in these six cases, the results suggest that lesions in the superior colliculi do not in

TABLE 4

SUMMARY OF THE LESIONS FOUND IN THE VISUAL CENTERS OF THE OPERATED ANIMALS

Plus signs show that lesions were found in the structures which are indicated as captions to the columns Minus signs indicate the absence of lesions No attempt was made in this table to indicate the extent of lesions The first column indicates the animal and side of the brain in which the lesions were found. *SC* = Superior colliculus *w* = Area *w* of the cortex *LG* = Lateral geniculate body *OpTh* = Optic thalamus *OpF* = Fibers of the optic tract dorsal to the lateral geniculate body *TrLD* = Trials required to learn the light-darkness habit *TrBW* = Trials required to learn the black-white habit.

Rat		*SC*	*w*	*LG*	*OpTh*	*OpF*	*TrLd*	*TrBW*
8	R	+	—	—	—	+	174	59
	L	+	—	—	—	—		
9	R	—	—	—	+	+	104	315
	L	+	—	—	—	+		
10	R	+	—	—	+	+	70	219
	L	+	—	—	—	+		
11	R	+	—	+	+	—	—	72
12	R	+	+	—	+	+	220	139
	L	+	+	—	—	+		
13	R	+	+	—	—	+	179	44
14	R	+	—	+	+	+	110	8
	L	+	—	—	—	—		
15	R	+	—	—	+	+	214	96
	L	+	—	—	—	—		
16	R	+	—	+	+	+	—	142
	L	+	—	—	—	—		
17	R	+	—	+	+	+	137	57
	L	+	—	—	—	—		
18	R	+	—	—	—	—	119	—
	L	+	—	+	+	+		
19	R	+	—	+	+	+	179	5
	L	+	+	—	—	—		
20	R	+	—	—	+	+	158	—
	L	+	+	—	—	+		
21	R	+	—	+	+	+	313	—
	L	+	—	+	+	+		
22	R	+	+	+	+	+	307	—
	L	—	+	+	+	+		
23	R	+	+	+	+	+	279	—
	L	+	+	—	—	+		
24	R	+	+	+	+	+	900F	—
	L	+	+	+	+	+		

themselves cause a retardation in learning to discriminate light from darkness

Small unilateral lesions in the thalami had occurred in all but one (No. 13) of the group of cases numbered from 9 to 20. Only cases 12 and 15 gave any indication of a slight retardation in the Yerkes' box, and the thalamic lesions in these two animals were no larger than those of cases 18 and 20 which learned normally. These results indicate that small unilateral lesions in the optic thalami do not retard formation of the light-darkness habit.

Interruption of optic fibers to the colliculi and optic thalami had occurred in animals 8, 12, 13, 15, 17, 18, 19, 20, 21, 22, 23, and 24 Of these, only cases 21, 22, 23, and 24 were retarded in the discrimination of light from darkness. The interruption was only bilateral in Nos. 21, 23, and 24 and even in these three cases severance of the colliculi and optic thalami from the optic tracts was not complete, for in no case were the fibers going through the lateral geniculate nuclei to these bodies completely transected As fibers from the optic tracts dorsal to the lateral geniculate nuclei go both to the optic thalami and the superior colliculi, severance of these fibers in Nos. 21, 23, and 24 served to give little information regarding the relative importance of each of these nuclei.

Cases 21-24 were the only seriously retarded animals in learning to choose the illuminated alleyway in the Yerkes' box In No 21 there were severe bilateral lesions in the optic thalami, and both lateral geniculate bodies were about half destroyed. Serious but not complete destruction occurred in the geniculo-striate system of Nos. 22 and 23 bilaterally, but in No 24 this system was destroyed. Optic thalamic lesions in Nos. 22 and 23 were mainly unilateral, but in No. 24 they were bilateral These results show that severe bilateral thalamic and cortical destructions (No 24) prevent formation of the light-darkness habit, whereas pronounced retardation is produced with only unilateral optic thalamic lesion plus bilateral geniculo-striate destruction (Nos 22 and 23) These findings are similar to those found by Lashley (7) in his rats with respect to the relearning of this habit.

2. *The Black-White Problem* On the jumping platform in the habit involving discrimination between black and white, there were eight animals, Nos. 8, 9, 10, 11, 12, 15, 16, and 17 which were retarded, and one animal, No. 3, which failed. Of these cases, the

cortical visual areas were involved only in case 12, and the lateral geniculate nuclei only in cases 11, 16, and 17. As the records for these four animals in the discrimination of patterns were normal, we have evidence that the geniculo-striate system was sufficiently intact for normal functioning and that the retardation in the first jumping problem was not due to injury in these regions.

The superior colliculi were involved in each of these retarded cases, yet in animal No 9, which was the most seriously retarded case on this problem, the superior colliculus on the left was only slightly involved while that on the right was intact. Likewise in case 10, the colliculi were almost intact but the optic fibers at the lateral extension of the anterior margin of both colliculi were invaded. Animal 11 was retarded but the lesion was confined to the right superior colliculus. On the other hand, case 14 with lesion involving the posterior three-fourths of the superior colliculi behaved normally on this problem.

In all these retarded cases of learning the black-white habit, the *lesions in the colliculi were located in the anterior portions of these nuclei.* In the first part of this paper we considered seven animals which behaved normally in learning this problem. The lesions in these seven cases were confined entirely to the superior colliculi, but in no case were they located anteriorly in these nuclei as they were in the eight cases which were retarded. There were only two animals, Nos. 13 and 19, with lesions in the anterior parts of their colliculi which were not retarded on this problem.

Seven of the cases which were retarded in learning the black-white discrimination had lesions which invaded their optic thalami. In these cases (Nos. 9, 10, 11, 12, 15, 16, and 17) the lesions were located just rostral or lateral to the anterior portions of the superior colliculi, together with involvement of optic fibers to the thalami and colliculi in this lateral region. In case No. 8 there was no direct lesion in the thalami, but the optic fibers at the lateral extension of the anterior tip of the superior colliculus on the right was invaded. Animal 13, although not as severely retarded as the eight cases just considered, had a slight interruption of its optic fibers in the same region as that of No. 8.

The two most retarded cases on the black-white discrimination had bilateral lesions either in the optic thalami or in the fibers to these nuclei. The thalamic lesions in all other cases which were retarded on this problem were unilateral. Although no attempt was made to arrange the cases in a series based upon the severity of lesions in the optic thalami or in the optic tract fibers at the lateral and anterior area of the superior colliculi, a superficial examination reveals the existence of a slight direct correlation between extent of lesion in these areas and retardation on the black-white jumping problem

Animal No. 3 failed on this problem. Its failure on this situation can hardly be ascribed to its cerebral lesion after a comparison of its lesion with those in Nos 6 and 14, for lesions in these cases did not retard learning

Two animals, Nos 14 and 19, had unilateral lesions in their primary visual centers and they were not retarded on this problem. In No. 14, the lesion undercut a portion of the lateral nucleus of the thalamus in the region of the posterior third of the habenula, and transected a few fibers on the mesial anterior surface of the pretectal region. The lesion in No 19 invaded the optic thalamus caudal to the anterior tip of the right superior colliculus

This evidence, although confusing, indicates that lesions occurring in the anterior parts of the superior colliculi are more detrimental to the formation of the black-white jumping habit than lesions in the posterior region. It points to the view that lesions in the superior colliculi are not detrimental per se, but that lesions in the optic thalami, either just rostral, lateral, or ventral to the anterior tip of the superior colliculi, or lesions involving the optic fibers to these areas, retard formation of the habit. There is some evidence which indicates that retardation is roughly proportional to severity of lesions in the optic thalami.

CASES SHOWING ABNORMAL JUMPING BEHAVIOR

Lashley (4) and Lashley and Frank (8) have reported that animals with lesions in the superior colliculi would not jump, and behaved on the jumping stand as animals blinded by enucleation of their eyeballs. In the present experiment, animals 18, 20, 21, 23, and 24 would not jump and animals 3, 8, 10, and 22 were given from one to three weeks of preliminary training before they would risk a leap of 25 centimeters Case 22, after commencing to jump, refused after making 10 responses and could not be urged to risk more attempts. As about 5 per cent of normal animals fail to jump, the high percentage of failures and those reluctant to jump in this report cannot be explained on the basis of normal animals which fail, but must be ascribed to their midbrain and thalamic lesions.

DISCUSSION

In case 21 the visual cortex was not injured and both lateral geniculate bodies were over half intact, yet this animal was seriously retarded. However, severe bilateral lesions were found in the primary thalamic and midbrain centers of this rat.

In view of Lashley's recent findings about the all-or-none function of the visual cortex in the discrimination of light from darkness, it is difficult to understand why this case should have been so retarded on this problem. Lashley's idea of equipotentiality assumes that the visual cortex and some other area are equally potential in this habit. If this equipotentiality is reciprocal, then in case 21 no retardation should have occurred since the geniculo-striate system was over half intact. What bearing this case may have on the theory of equipotentiality and the neural mechanisms involved in the learning of this habit can only be determined by future research.

SUMMARY

The superior colliculi were operated upon in 24 rats. Following recovery, the animals were trained in a Yerkes' discrimination box to choose the illuminated alleyway. They were also trained on a jumping apparatus to choose: (*a*) a small white square and avoid a black one, and (*b*) horizontal striae in preference to vertical striae.

Lesions undercutting or destroying the posterior three-fourths of each superior colliculus in rats do not prevent normal formation of the light-darkness discrimination habit in the Yerkes' box.

Small unilateral lesions in the optic thalamus do not retard formation of a habit involving the discrimination of light from darkness.

Severe bilateral lesions in the geniculo-striate system plus severe unilateral lesions in the optic thalamus and midbrain regions produce a retardation, while complete bilateral destruction of these areas prevents formation of a habit based on the discrimination of light from darkness

Lesions in the anterior parts of the superior colliculi, involving the optic thalami or optic fibers to the thalami and midbrain in this region, produce retardation on the jumping stand in learning the black-white discrimination habit

There is a suggestion that it is the optic thalami in the immediate vicinity of the anterior part of the superior colliculi which, when invaded, produce retardation in learning to discriminate black from white on the jumping stand There is some evidence which indicates that retardation in learning the black-white discrimination is roughly proportional to the severity of the optic thalamic lesion

An unusually large percentage of cases with lesions in the superior colliculi and optic thalami show abnormal jumping behavior

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TERRITORIAL BEHAVIOR OF NORMAL AND CASTRATED FEMALES OF *ANOLIS CAROLINENSIS**

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INTRODUCTION

It is well known that females as well as males of various species of birds defend their territory against intruders (Howard 3, 4, Kinsey 5, Michener and Michener 6). Territoriality among male lizards has been reported by Newman and Patterson (7), Noble and Bradley (8), Rollinat (9), and Wiedemann (10) No one, apparently, has described it for female lizards.

After conducting experiments on dominance and territoriality of normal male *Anolis carolinensis* (1) and also on both male and female castrates of the same species (2), it was discovered that even the normal female of this species exhibits marked territoriality, as evidenced by the promptness with which she attacks a strange female intruder on her territory.

The following report is an account of experiments which demonstrate the territorial behavior of normal and castrated females of *Anolis carolinensis.* The castrates used are part of the group for which fighting and dominance behavior has been described (2).

MATERIALS

The lizards used were nine normal females shipped from Louisiana in February 1935 and four other females shipped in February 1934 and bilaterally castrated during the first week of June, 1934 The experiment extended from July 19 to September 20, 1935

The animals were fed daily on live flies, occasional spiders, and Tenebrio larvae; at intervals they received small doses of orange juice and cod-liver oil Ultra-violet irradiation was administered for short periods, especially during the winter and spring months. The cages, two feet square, were placed in windows receiving the afternoon sun. They were sprinkled with water once a day Gravel, branches, bark, and potted plants were placed in each cage.

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TABLE 1

Weights in grams

Normal		Castrates	
BA	2.45	A	3.5
BB	2.0	B	3.0
BC	2.7	C	3.1
BD	2.7	D***	3.26
BE*	2.5		
BF	2.3	Average	3.2
BG**	2.4		
BH	2.35		
BI	2.6		
Average	2.44		

*Died 7/22/35 **Died 8/1/35 ***Died 9/1/35

DESCRIPTION

Table 1 gives the name and average weight of each animal studied. The weights fluctuated slightly during the course of the experiment. Gains and losses were irregular; some gained as much as four tenths of a gram while others lost as much in the same period and under identical conditions of environment

Each female, with the exception of BH and BF, was placed alone in a cage BH shared a cage with male Q (same species) whose behavior has been described (1), BF shared a cage with one gecko (*Hemidactylus turcicus*) with which she seemed to live quite contentedly, the two often sharing the same narrow crevice in a particular piece of bark Each female remained in her own cage during the entire experiment except for the few minutes every second or third day when she was used as an intruder in another cage. Only rarely were records secured daily since it was found that much more consistent behavior resulted when the animals were left undisturbed (except for the daily feeding and watering) for at least 48 hours Sunshine was also requisite to consistent territorial behavior

When a female is placed in a strange cage, the following are the usual activities The stranger invariably licks the branch or other substratum on which she happens to find herself. A resident never does this. The stranger clearly recognizes a change in her environment for she gazes about her new surroundings with great intentness and curiosity and frequently sets forth to explore every part of the cage. As she is moving about thus, she suddenly catches sight of the resident female who has been watching the intruder from the moment she entered the cage. This is the signal for the resident to rise up on all four feet, extend the small fan-like dewlap on her throat, and flatten her body laterally (to such a degree that, when observed from above, her head is the widest part of her body) as her body touches the substratum At the same time she bobs her head as she rises up and down on her forelegs. Then, with mouth open to bite, she springs at the non-resident which usually turns and escapes as rapidly as possible.

To secure the best evidence of territoriality four categories of encounters were arranged. I. Normal resident versus normal non-resident. II Normal resident versus castrate non-resident. III. Castrate resident versus castrate non-resident. IV Castrate resident versus normal non-resident. Each of the thirteen females played the rôle of resident and non-resident alternately. For convenience in referring to the terms resident and non-resident, the abbreviations *R* and *NR*, respectively, will be used.

The greatest care was taken to follow the same routine each time in placing *NR* in the cage of *R*. The observer placed female *NR* on the inside of the screen door, closed it quietly, and withdrew about five feet to await developments. Experience enables one to catch and hold the lizard with only just enough pressure to prevent its escape from the fingers. When caught its actions indicate that it is more angry than frightened since it bites viciously at the fingers. Furthermore, when released into the strange cage, its obvious and immediate interest in the new surroundings seems to indicate that it has completely recovered from whatever emotional disturbance it might have suffered from being caught and held in the fingers a moment before. Handling of the lizards, then, plays a very minor rôle in determining their behavior since in 18 encounters female *NR* replied to the challenge of the female *R* in like manner. Whatever part it does play, it affects for the most part only the immediate behavior of the *NR* whereas the actual evidence of territoriality arises chiefly from the behavior of the *R*. It is a fact that lizards which were not given the opportunity of expressing their territorial or fighting reflexes were definitely less alert, and in some cases were less healthy than those which were allowed to express these reflexes. The latter were certainly handled more than the former

In category I (normal *R* versus normal *NR*) there was a total of 66 encounters. Of this total, 16 encounters showed no response on the part of either *R* or *NR*, while in 44 encounters *R* alone showed combativeness to the extent of chasing *NR* from the field. These 44 combats give definite evidence of territoriality In six encounters normal *NR* showed combativeness by giving the very characteristic dewlap display, et cetera, as described above, but in four of these six cases *R* returned the challenge and quickly defeated *NR*. In the other two cases *NR* challenged and chased *R* which made no challenge or other combative gesture

In category II (normal *R* versus castrate *NR*) a total of 29 encounters was recorded. In 17 of these only *R* challenged and drove away *NR* In nine encounters both *R* and *NR* showed combativeness by challenging each other, but in only one of these did castrate *NR* win the combat by chasing away normal *R*. The reason for this high percentage of castrate *NR* combativeness in category II will be taken up later. No response was observed on the part of either *R* or *NR* in three encounters

In category III (castrate *R* versus castrate *NR*) a total of 42 encounters was observed. In 36 of these *R* alone showed combativeness by alternately challenging, biting, and chasing *NR* which retreated and often hid to escape the persistent onslaughts These attacks of castrate *R* were not only more vicious and more quickly launched but were continued for a longer period than those of normal *R* in category I Four encounters showed combativeness on the part of *NR*, but in each case *R* decisively defeated *NR*. In two cases no response was elicited by either *R* or *NR*. In each of these two encounters the castrate *R* happened to be female D which was sick at the time and died soon after.

In category IV (castrate *R* versus normal *NR*) 24 combats were registered In all of these only castrate *R* was combative The normal *NR* retreated without giving any challenging reaction

Table 2 records every encounter in which each female took part, as *R* and also as *NR*.

The mere combative response of both normal and castrate female *R* against *NR* is strong evidence of territoriality Although both types of *R* females become combative against *NR*, if the behavior is compared, interesting differences are brought out.

Although 150 normal females have been under daily observation

TABLE 2

RECORD OF 161 ENCOUNTERS OF NORMAL AND CASTRATED FEMALES

		Residents												
		Normals									Castrates			
		BA	BB	BC	BD	BE	BF	BG	BH	BI	A	B	C	D
Non-residents Normals	BA		4	1	1‡	*	1	1	3	1	2			
	BB	3‡		1	‡			‡			1	2		
	BC	1‡	‡		5		1		2	1‡		2	2	
	BD	1	1	2‡*					1	1‡	1		2	
	BE											1		
	BF	1‡‡	1	‡						3	1	1		1
	BG	1							1	‡				
	BH	1**			*					1	1	1		1
	BI			1	1		2‡‡*		1			1		
Castrates	A	1			1	3			4	2*		5	2*	1‡‡*
	B	*		1**	1	1	2	1	2		3*		2*	3
	C	‡			1*		*			1*	4	4		3
	D	1								*	4	4	4	

Arabic numerals—Encounters in which only the resident showed combativeness by chasing away the non-resident.

* Encounters in which the non-resident showed combativeness

‡ Encounters in which neither resident nor non-resident gave any response.

at Harvard during the past two years, not a single case of combativeness was noted among them. Apparently the reason lies in the fact that the normal female lacks any observable urge or tendency to express its dominance over other females that reside habitually in the same cage with it. This is quite unlike the male which, as has been described (1), possesses a very strong urge to dominate as well as to hold territory. The castrated female resembles the male in this regard but to a lesser degree; it exhibits combativeness toward and dominance over other females and smaller males in the same cage. Moreover, castrated females in the same cage with males that are fighting sometimes imitate the fighting postures of the males (2).

Usually the castrate female *R* challenges, by means of dewlap display and flattening of the sides of the body, from whatever spot she happens to be when the intruder enters the cage She then advances slowly, stopping frequently to strut with extended dewlap. Then she will charge swiftly with mouth open to bite *NR*, unless the latter is quick enough to avoid her

The normal female *R* sometimes duplicates the behavior of the castrate *R*, but more often she merely watches *NR* intently for a short time. Then she suddenly runs at *NR* with mouth open, but stops when about two inches away, where she proceeds to challenge and strut for a few seconds. Suddenly she leaps at the stranger to bite her and then chases her about the cage, unless *NR* has already retreated before this final attack is launched.

Details of the data contained in Table 3 will be elaborated in the following paragraphs.

The time interval elapsing from the moment an intruder is placed in the cage until *R* responds with the challenge or pursuit is termed the reaction time. Where only *R* shows combativeness, this reaction time of *R* in each of the four categories of encounters is as follows:

I Normal *R* vs. normal *NR* The average reaction time of 44 encounters was 6 18 minutes.

II. Normal *R* vs. castrate *NR* The average reaction time of 17 encounters was 5.2 minutes.

III. Castrate *R* vs. castrate *NR*. The average for 36 encounters was 1.25 minutes

IV. Castrate *R* vs normal *NR*. The average for 24 encounters was 1.0 minute

These figures indicate that castrate *R* gives objective evidence of territoriality by challenging NR in from 1/4 to 1/5 the time required for the normal *R* to give the same observable response.

A further difference in the behavior between the castrate and the normal lies in the number of encounters wherein there was no response elicited In category I, 16 non-responses (24 per cent) out of 66 encounters are recorded In category II there were three non-responses (*10.0* per cent) out of *29* encounters. In category III there were two non-responses (4 7 per cent) out of a total of 42 encounters Category IV gives no non-responses out of a total of 24 encounters.

Turning now to the combativeness of *NR* in the four categories of encounters, we find the following:

Category I Four cases of *NR* combativeness out of 66 encounters are on record, but *R* defeated *NR* in each of these cases. Two cases show that normal *NR* alone gave evidence of combativeness. The percentage of normal *NR* combativeness was 9.2 per cent

Category II. Nine encounters (31 per cent) out of a total of 29 encounters is the record of combativeness on the part of castrate *NR*. However, in only one of these nine cases did *R* fail to show combativeness

Category III. Four out of 42 encounters showed combativeness on the part of castrate *NR* but in each case castrate *R* defeated *NR* This represents 9 5 per cent combativeness in this category.

Category IV. In this group there were no cases of *NR* combativeness out of a total of 24 encounters

Regarding instances where the resident failed to respond combatively while the non-resident did so, it is noted that the percentages of such encounters in each category are· I—3.0 per cent, II—3 4 per cent, III—0 0 per cent, IV—0 0 per cent

DISCUSSION

That females of *Anolis carolinensis,* whether normal or castrated, exhibit combativeness has been adequately demonstrated by the foregoing description, although Noble and Bradley (8) have stated that females never do so That the combativeness arises as an element in the urge to hold territory is proven by the fact that when a normal female is *R,* she not only defeats the normal *NR* in 73.3 per cent of the encounters, but is the only one of the two individuals concerned to exhibit combativeness. When the same normal female is *NR*, she shows combativeness in only 9.2 per cent of the encounters and in 3 per cent of the encounters she is the sole combatant. The territoriality of the castrate *R* is even more strongly expressed as opposed to the castrate *NR*, showing combativeness in 90 per cent of the encounters, while the same castrate as *NR* shows only 9 5 per cent This is brought out in Tables 2 and 3.

It seems obvious that the marked difference in behavior of castrates and normals is best explained by the presence, or relative absence, of the ovarian hormone or hormones.

The following factors are discussed here individually, as they vary in the case of castrates or of normals.

A. Reaction time of *R*
B Average weight of *NR*
C Average weight of *R*
D. Percentage of *R* combativeness
E Percentage of non-responses of both *R* and *NR*
F Percentage of *NR* combativeness
G Percentage of non-responses of *R*, alone.

When these factors are considered separately, there seems to be little or no correlation between castrate and normal behavior but, when each factor is studied in its relation to the others, the real significance of the comparison between the two types of females is emphasized Figure 1 gives these factors graphically on a percentage basis and should be compared with Table 3.

In comparing factors *A* and *E* of categories I (normal *R* vs. normal *NR*) and III (castrate *R* vs castrate *NR*) it is noted that *A* (reaction time of *R*) and *E* (percentage of non-response of *R* and *NR*) are extremely high in category I and very low in category III. This indicates that the combativeness of the normal female is inhibited to a considerable extent by some agent which is believed to be the ovarian hormone or hormones

On the other hand, *F* (percentage of *NR* combativeness) is practically the same in categories I and III, being 9 2 per cent and 9 5 per cent, respectively. This fact is correlated with factor *B* (average weight of *NR*) and factor *C* (average weight of *R*) because size and weight of combatants is known to influence the outcome of an encounter (1). In category I both *R* and *NR* average the same in weight (2.44 grams) and this is also true in category III (3.2

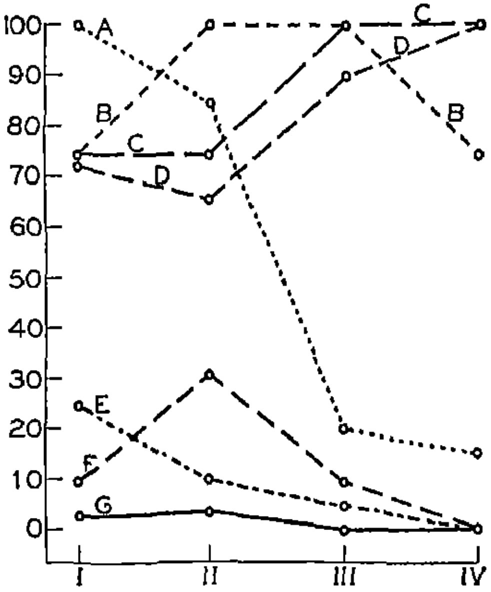

FIGURE 1

To show territorial behavior of normal and castrated females of *Anolis carolinensis* in four categories. I. Normal resident versus normal non-resident, II. Normal resident versus castrate non-resident, III. Castrate resident versus castrate non-resident, IV Castrate resident versus normal non-resident.

A—The reaction time of residents, in percentage, assuming that of resident of category I to be 100 per cent.

B—Average weight of non-resident in percentage, assuming that the normal female is 76 per cent of the weight of castrate.

C—Average weight of resident in percentage

D—Percentage of resident combativeness

E—Percentage of non-responses of both resident and non-resident.

F—Percentage of non-resident combativeness

G—Percentage of resident negative responses with non-resident combativeness.

grams). This explains, perhaps, why *NR* combativeness is practically the same in categories I and III

In category II (normal *R* vs. castrate *NR*) and in category IV (castrate *R* vs normal *NR*) it is noted that factor *D* (combativeness of *R*) is 65 per cent in II and 100 per cent in IV. Obviously factor *B* (average weight in *NR*) plays a part in determining the

TABLE 3

	I Normal *R** vs normal *NR*	II Normal *R* vs. castrate *NR*	III Castrate *R* vs castrate *NR*	IV Castrate *R* vs normal *NR*
Total encounters	66	29	42	24
Non-responses of both *NR* and *R*	16	3	2	0
Cases of combativeness of *R* with retreat response of *NR*	44	17	36	24
Total cases of *NR* combativeness	6	9	4	0
Cases of *NR* combativeness with non-response of resident	2	1	0	0
Average reaction time (minutes) of *R* with non-response of *NR*	6.18	5.2	1.25	1.0
Percentage of *R* combativeness with retreat response of *NR*	73.3%	65.4%	90.0%	100.0%
Percentage of *NR* combativeness	9.2%	31.0%	9.5%	0.0%
Percentage of non-response of *R* and *NR*	24.0%	10.0%	4.7%	0.0%
Percentage of combativeness of *NR* with non-response of *R*	3.0%	3.4%	0.0%	0.0%
Average weight of *R* in grams	2.44	2.44	3.2	3.2
Average weight of *NR* in grams	2.44	3.2	3.2	2.44

**R*—resident, *NR*—non-resident.

difference in percentage of combativeness of II and IV. In category II the *NR* is a castrate and weighs 3.2 grams while the normal *R* weighs only 2.44 grams. In category IV the *NR* is a normal and weighs 2.44 grams and the *R* is a castrate and weighs 3.2 grams. It is natural to suppose that the combativeness of normal *R* should drop from 73.3 per cent for an adversary of her own size to 65.5 per cent for a rival 24 per cent heavier. It should be mentioned in this connection that factor *D* (combativeness of *R*) is 73.3 per cent in category I and 90 per cent in category III. In other words, the castrate *R* is 16.7 per cent more combative when opposed by a castrate *NR* than is the normal *R* when opposed by a normal *NR*.

Whereas factor *F* (combativeness of *NR*) is equal in categories I and III, it is not so for categories II and IV. In II, where *R* is a normal and *NR* is a castrate weighing 24 per cent more, the combativeness of *NR* is 31 per cent while in IV, where the *R* is a castrate and the *NR* is 24 per cent lighter, the combativeness of *NR* is 0.0 per cent.

This complete lack of combativeness of the normal *NR* in category IV and the high percentage of combativeness of the castrate *NR* in category II is still easier to explain when it is recalled that the castrate *NR* in category II has three factors in her favor, a shorter reaction time, a weight advantage, and a greater intrinsic pugnacity than the normal *R*. In IV the normal *NR* is handicapped by being smaller and less pugnacious and by having a longer reaction time than the castrate *R*.

Even factor *G* (percentage of non-responses of *R* alone) shows that the castrate *R* in categories III and IV is more decisive and less inhibited than the normal *R* in categories I and II, as indicated by the record for each category. I—3 per cent, II—3.4 per cent, III—0.0 per cent, IV—0.0 per cent.

GENERAL SUMMARY

Territoriality is described for the first time in normal and castrated female lizards. Combativeness and the urge to defend territory are shown to be stronger in castrates than in normals as indicated in the four categories of encounters given in Table 4.

The average weight of the castrates was 24 per cent greater than that of controls. (Ovaries of castrates were removed 13 months before these experiments were begun.)

TABLE 4

	Normal *R** vs normal *NR*	Castrate *R* vs castrate *NR*	Normal *R* vs. castrate *NR*	Castrate *R* vs normal *NR*
Combativeness of resident	73.3%	90.0%	65.4%	100.0%
Combativeness of non-resident	9.2%	9.5%	31.0%	0.0%
Non-response encounters	24.0%	4.7%	10.0%	0.0%
Reaction time of resident (minutes)	6.18	1.25	5.2	1.0

**R—resident, NR—non-resident*

These details reveal strong evidence that the relative dissimilarity in territorial behavior of normal and castrated females is due to the presence or relative absence of the hormone or hormones secreted by the ovaries

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DIFFERENTIAL RESPONSES OF THE NEW-BORN CAT TO GUSTATORY STIMULI*

From the Psychological Laboratory of Brown University

CARL PFAFFMANN

The earliest reported observations upon the taste sensitivity in the new-born cat were those of Mills (3). Kittens two days old were found to suck vigorously when the tip of a feather moistened in milk was inserted in their mouths The same reactions occurred as well for salt, aloes (a bitter producing substance), and sugar solutions Animals six days old responded negatively to salt and aloes solutions as contrasted with the positive reaction to milk and sugar. On the ninth day, several animals were observed to lick a piece of candy as well as a crystal of sodium chloride. In the latter case, however, Mills describes the behavior as characteristically that of disgust. By the eleventh day, he notes that the responses to bitter were definitely those of avoidance.

Tilney and Casamajor (4) studied the reactive and receptive capacities of the fetal and new-born cat with especial reference to the relation between the onset of myelinization and the onset of neural function. They believe that the gustatory apparatus is of little importance in directing the behavior of these young organisms, since the kittens would approach and suck the female in a normal manner when the nipple was painted with quinine, petroleum, or with ether to dissolve and evaporate certain fatty substances. If, however, the nipple was coated with collodion so that its erectile character was lost, the response was distorted. The myelinization apparent in some of the cranial nerves supplying the mouth was considered in relation to the highly coordinated sucking responses to be observed in the new-born.

Langworthy (2), in further studies on the kitten, pointed out that the gustatory sensitivity of this animal had not been adequately tested and emphasized the fact that there are definite signs of myelin in the peripheral nerves of the mouth as well as the tractus solitarius, by

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way of which the taste fibers are assumed to pass to the higher centers.

A device making possible more delicate recording of gustatory sensitivity in the cat than has been possible in the past and the results of the use of this device are presented in this paper.

Apparatus and Procedure

The apparatus is a modification of that used by Jensen with human infants (1) and, as indicated in Figure 1, consists of a 25-cc. Erlenmeyer flask (*B*) fitted with a small rubber nipple (*N*) to serve as a nursing bottle Three additional small outlets had been added to the flask, two of these fitted with rubber sleeves so that a thermometer (*T*) and a medicine dropper (*D*) could be inserted into each. The other, in the base of the flask, was fitted with a stopcock (SC_2) and connected by rubber tubing (*H*) through a three-way stopcock (SC_1) to a U-tube water manometer (*U*) A cork float with an attached writing arm was inserted in the open arm of the manometer. One outlet of the three-way stopcock was open to the air so that the system could be opened or closed in order to return the pressure in the system to that of the atmosphere. A marker (*TM*) wired in series with a battery and metronome (*M*) indicated the time in seconds A long paper kymograph, controlled by a foot lever, was used.

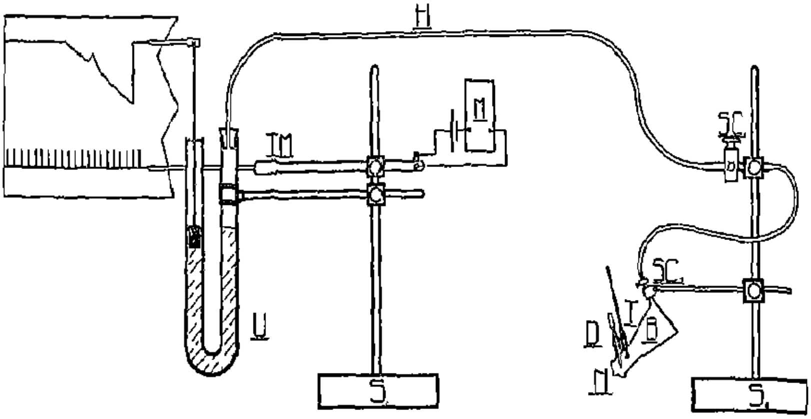

FIGURE 1
Diagram of the Apparatus

For an experimental trial, the medicine dropper filled with stimulating solution was inserted in the neck of the bottle containing warm cow's milk diluted with water in the ratio of 1 1. The bottle was then clamped in place at an angle of 20 - 25°, about two inches above the table surface. All stopcocks were opened and the cat held before the "artificial mother" When sucking movements began, the kymograph was started and the air system closed so that the pressure volume changes in the system would be accurately recorded by the manometer as milk was withdrawn through the nipple. Shortly after the beginning of the response, the solution in the medicine dropper would be mixed with that in the bottle by squeezing the bulb. The momentary pressure increase resulting from this manipulation appeared on the record as a slight jag or notch and served to indicate that point at which stimulation took place. Temperatures were recorded after each trial

Seven animals were used in the experiment, animals 1 and 2 from a litter born March 21, 1935, and animals 3, 4, 5, 6, and 7 from a litter born March 26, 1935 Animals 1, 2, and 3 were tested ten days after birth for a period of ten days. Each day during this period the animals were left with the female for 12 hours, tested at the end of approximately six hours, again six hours later, and then returned to the female This schedule was found necessary for maintaining the health of the kittens, since in this way they were cleaned and adequately fed during part of each day It was also noted that control of the sphincters at this early stage of development was apparently inadequate and that the stimulation of the sphincters by the female by licking was very important in bringing about elimination Animals 4, 5, 6, and 7 were isolated two hours after birth, fed artificially several times, tested once 18 hours after birth and again four hours later No further trials were carried out

RESULTS

Samples of the records are presented in Figure 2 Control record 1 illustrates the result when the milk contained in the nursing bottle slowly leaked out of the nipple, and control record 2, when the experimenter manipulated the nipple by hand to be contrasted with those records obtained when the animal actively sucked Each step-like formation on the records of this latter group was assumed to represent an individual suck since the movements of the animal's jaw and

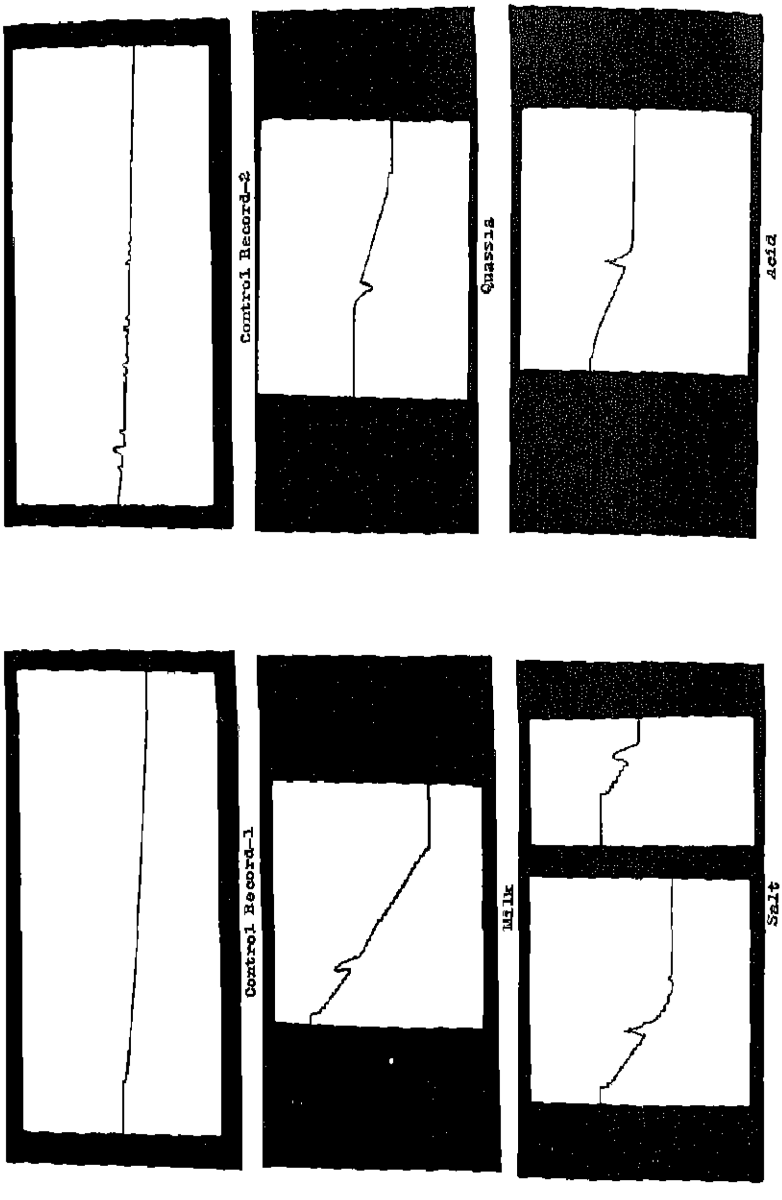

FIGURE 2
SAMPLE RECORDS

mouth when feeding appeared to be synchronized with each downward displacement of the writing arm. The response to milk indicates that the momentary pressure increase occasioned by pressing the bulb of the medicine dropper, when this contained water alone, *did not distort the response*, whereas the addition of taste stimuli by such manipulation, as indicated accordingly in the other records, did modify the response. Such modified responses, characterized by the change in slope and regularity of the curves, were designated as negative or differential. The undistorted responses were classified as positive or normal. The average number of sucks following the addition of each of the solutions was also taken to be indicative of whether a differential response had occurred. Both measures are included in each of the following tables

1. *Responses of the Day-Old Cat to Sodium Chloride.* Animals 4, 5, 6, and 7, as described above, were tested during the first day after birth. In this case, an effort was made to obtain two curves at each experimental period, namely, a control record in which the effect of the pressure increase alone, and a test record, in which the effect of the salt solution (NaCl 1 M concentration),[1] was determined. In some cases it was not possible to obtain two such records.

Table 1 summarizes the responses of the day-old cat. In the first

TABLE 1
SUMMARY OF THE RESPONSES DURING THE FIRST DAY

Temp. 30-34° C. Starvation period, 4-6 hours

Animal	Age in hours	Milk	Salt
4	18	+	x
5	18	+	x
6	18	+	— ?
5	22	+	— ?
4	22	+	—
6	22	+	—
7	22	x	—
Total + responses		6	0
Total — responses		0	5
Average number of sucks		17	8 4

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[1] It should be pointed out that this concentration refers only to that contained in the medicine dropper. Since it was impossible to determine the exact concentration stimulating the animal, no attempt was made to ascertain the concentration used with the older animals, the only control of this factor being in the use of the same concentration of a given stimulating solution throughout the entire experiment.

three trials given at 18 hours, the control tests were given first, whereas in the other trials, the salt tests were followed by the controls It will be seen that milk alone always resulted in a positive or undistorted response whereas the addition of salt disrupted the sucking. In two cases the responses were questionable; in one, the nature of the response suggested that the pressure interfered with the response, and in the second, the sucking was irregular before as well as after the addition of salt. Fewer individual sucks occurred after the addition of salt than after the addition of plain water. It is therefore concluded that gustatory sensitivity to salt has been demonstrated in the new-born cat

2. *Responses during the Ten- to Twenty-Day Periods.* Three animals, 1, 2, and 3, were tested twice a day for a period of ten days, each test series being preceded by a starvation period of approximately the same duration, as described above. In some cases several records could be obtained during a single test period, while at other times none were obtained.

Table 2 summarizes the responses during the ten- to twenty-day period when salt, quassia (bitter producing), and acid were added to milk, as well as the positive responses obtained from milk alone and from sweetened water after the same animal had consistently refused to suck plain water. The plus column indicates the number of undistorted responses, the minus column the distorted or differential responses for each of the several conditions. The evidence for acid and sugar sensitivity is incomplete, but is presented as an item of interest Since the total number of negative responses increases and the average number of sucks decreases with the addition of quassia, salt, and acid it is concluded that gustatory sensitivity to substances

TABLE 2

SUMMARY TO THE RESPONSES DURING THE 10- TO 20-DAY PERIOD AFTER BIRTH

	Temp. 34-38°		Starvation period, 5-8 hours.							
	Milk		Salt		Quassia		Acid		Sugar	
Animal	+	—	+	—	+	—	+	—	+	—
1	3	2	0	5	1	3	0	1	x	x
2	6	0	0	3	1	3	0	1	x	x
3	4	0	0	1	2	1	x	x	1	0
Total	13	2	0	9	4	7	0	2	1	0
Average number of sucks	15 7		3 7		8 1		5 5			x

usually described as salty, bitter, and sour in taste has been demonstrated. Also since these animals refused water, but accepted milk and water, and since the one animal tested with a solution of sugar and water accepted this, it is concluded that sensitivity to substances usually described as sweet in taste is indicated.

Summary

1. A method for investigating the gustatory sensitivity in the new-born mammal, the cat, has been described.
2. The day-old cat has been shown to respond differentially to a mixture of sodium chloride and milk.
3. The ten-day-old cat has been shown to respond differentially to stimuli which usually give rise to the taste qualities of salt and bitter. Sensitivity to substances usually giving rise to a sweet and sour taste is also indicated.
4. The results of the present investigation are considered as preliminary, merely respresenting some qualitative observations by means of an accurate and controlled method for gustatory experimentation on young mammals.

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INTERLINKAGE OF SENSORY MEMORIES IN RELATION TO TRAINING IN DRAWING*

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THE PROBLEM

Whenever there is occasion to watch an adult attempting to draw a picture of some object familiar to him or trying to sketch a map or a setting that he wants to explain, one will observe that he has great difficulty in giving a graphic presentation of that which he has in mind, and that the result will be primitive or childish

Observations of this kind have induced the question, Why is it that an adult, mature in his verbal or written expression and able to give in words a fairly accurate description, fails so considerably when drawing? Is it lack of manual ability? Is it lack of memory of the objects he has been asked to draw? Or is it the kind of memory which retains the object in a form unfit for graphic presentation?

In the following an attempt is made to answer these questions and to throw some light on the interesting fact that our abilities in graphic presentation are far behind our abilities in verbal presentation.

THE EXPERIMENT

The experiment consisted in drawing the following objects from memory.

Violin
Chair
Church
Duck
Horse
Man, woman, child
Flower (the one you know or like best)
Tree (the one you know or like best)
Automobile
Town street or country road (which extends away from the place on which you imagine you are standing. Draw some objects along side the street or road)

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The *objects enumerated* above were selected for this drawing test so as to be able to compare the results with the results of similar tests given by Georg Kerschensteiner in 1905 to some 50,000 Munich school children of ages six to 14 The only difference between the two tests consists in the addition of the automobile, the specification as to the flower and tree, and in narrowing down Kerschensteiner's perspective test to "a town street or country road" with the observer standing on it and the street extending away from him into the distance. This helped to avoid misunderstandings and led to results which were ready for interpretation as to correctness of drawing

A pencil and white paper were the materials used for the drawing. One hundred seventy adults were tested · 74 men, and 96 women. The ages of the persons tested are shown in the following table.

TABLE 1

Age	Men	Women	Men—percentage	Women—percentage
Up to 20	17	29	23	30
21 to 25	17	28	23	29
26 to 30	6	6	8	6
31 to 35	7	4	9	4
36 to 40	10	8	13	8½
41 to 45	3	8	4	8½
46 to 50	5	6	6½	6
51 to 55	6	4	8	4
56 to 60	1	2	1½	2
61 to 65	1		1½	
66 to 70		1		1

The distribution according to race of the persons tested was · white race 146, yellow race 8, and black race 16

After the completion of the drawings the following questionnaire was answered.

Time:

Please put the same name on this paper and on your drawings

Kindly answer the following questions ·

1 American? If not, what nationality and schooling?
2. Age?
3 Righthanded?
4 What profession do you, did you or are you going to practice?

5. Father's profession or activity?
6. Did you draw, when a child, at home (just for the fun of it)?
7. Did you draw in school? What were you supposed to draw in school?
8. Flowers?
9. All kinds of objects?
10. Living things?
11. From memory?
12. Did you copy?
13. Are you deft with your hands in making things?
14. Are you awkward?
15. Which object do you think was the most difficult to draw in this experiment?
16. Try to give an account how you proceeded mentally when you were making these drawings?
17. If you had a distinct picture in your mind of the object you were to draw, did you try to follow the shape of this picture intuitively with your hand just as you would when copying a picture or a real object?
18. Or, did you try to remember how this object was made, of what parts it consisted, how long and wide these parts were, what was its moving mechanism and did you then reconstruct it accordingly?

RESULTS

Regardless of the training, general intelligence or profession of the person tested, the drawings they produced showed a strong likeness to the drawings of children who have received practically no training and whose graphic development has not been interfered with. This likeness corresponds to drawings by children of different ages and stages of development.

Presentation of Drawing In following Kerschensteiner's description of the developmental stages of children's drawings, we refer to them as schematic or formula (formalized) presentation (Schema), presentation true to appearance (*erscheinungsgemaess*), and presentation true to form (*formgemaess*).

As schematic presentation we may designate the drawing of symbols for certain characteristics of the object presented. The child knows these symbols which he works out, combines, and unifies them into a whole picture. He uses these symbols in much the same way as an alphabet is used during a certain stage of mental development. The different symbols so employed are characteristic for the individual creating them The picture thus created is neither true to appearance nor true to form and nature. However, it is true and faultless according to the child's own logical knowledge of the structure, growth or "make" of things in the abstract sense. The shape of the object is only vaguely observed. Details are added as additional facts are remembered and connected with or inserted into the main outline. Hence, for example, the transparency (Figure 4, 35, 36) of many children's as well as adults' drawings. Correct proportion is rather an accident, certainly an exception to the rule of the schematic drawing. The drawing does not take into account the impossibility of a simultaneous front, side, or back view. Instead, the presentation is such that the observer seems to have changed his position and drawn the sum of his observations into one picture (Figure 3, 16, 17)

The presentation true to appearance gives a picture in correct proportions as to size The shape of the object as a whole and the details are fairly correct. The whole presentation, however, is two-dimensional, that is, depth, foreshortening, and distance are still disregarded (Figure 3, 21, 22, 26; Figure 4, 41, 42, 43)

The presentation true to form has all the characteristics of the presentation true to appearance, yet attempts successfully a graphic outline of depth, foreshortening, and distance—it is a perspective drawing (Figure 1, 5; Figure 3, 25, Figure 2, 9).

Kerschensteiner has classified the results of his drawing tests under these three headings, schematic presentation, presentation true to appearance, presentation true to form, and their intermediate stages, the development naturally being a continuous one gradually growing from one stage into the next

The drawings of the 170 adults who participated in the experiment show an overwhelming number of qualities of the schematic or formula stage, that is, they compare with the drawings of untrained children, chiefly between the ages of six and 10. (Figure 1, 1, 2, 3, 6, 7; Figure 2, 10, 11, 12, 13, 14, 15; Figure 3, 16, 17, 18, 19, 23, 24, 27, 28, 29, 30; Figure 4, 31, 32, 33, 34, 35, 36, 39, 40, 45, 46, 47, 49, 50.)

The best developed drawings, entirely true to appearance and

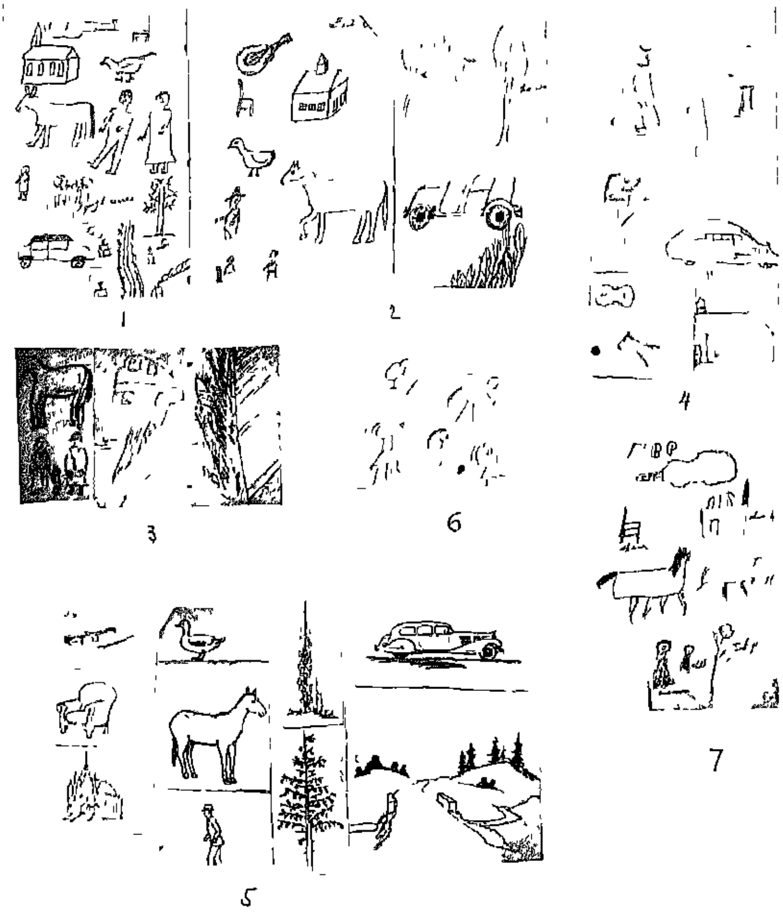
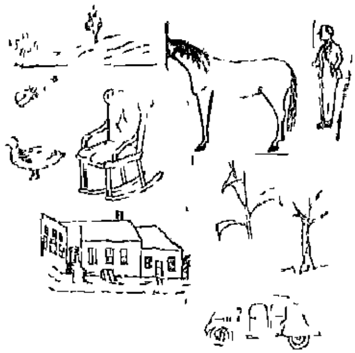


FIGURE 1

1 51-year-old farmer, tried to reconstruct mental picture "by thinking years back"
2 21-year-old engineering student, father—farmer, no drawing in school
3 36-year-old theoretical scientist, one year of art school
4 38-year-old farmer, reconstructs mental picture, never drew at all
5 19-year-old engineering student, drew at home and at school, reconstructs his mental picture "remember any details I can recall from past experiences"
6 50-year-old Negro woman
7 53-year-old Negro, house servant



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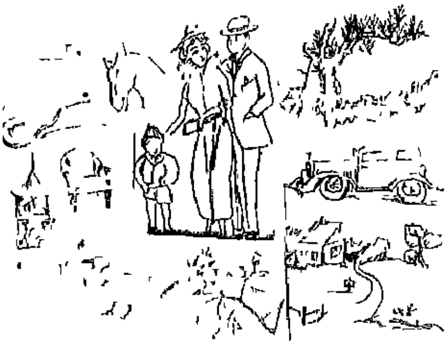

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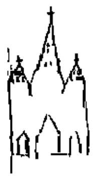

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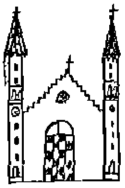

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FIGURE 2

8 46-year-old negro chauffeur, emphasized the numerous details he remembered; mentioned that he notices living things better
9 26-year-old Chinese engineering student, remarked that he thought first of everything he wanted to draw and that "must bring it to your mind"
10 Drawn by adult.
11 Drawn by 7-year-old child *
12 Drawn by 9-year-old child.*
13 Drawn by adult
14 Drawn by adult
15. Drawn by 9-year-old child *
*From Georg Kerschensteiner

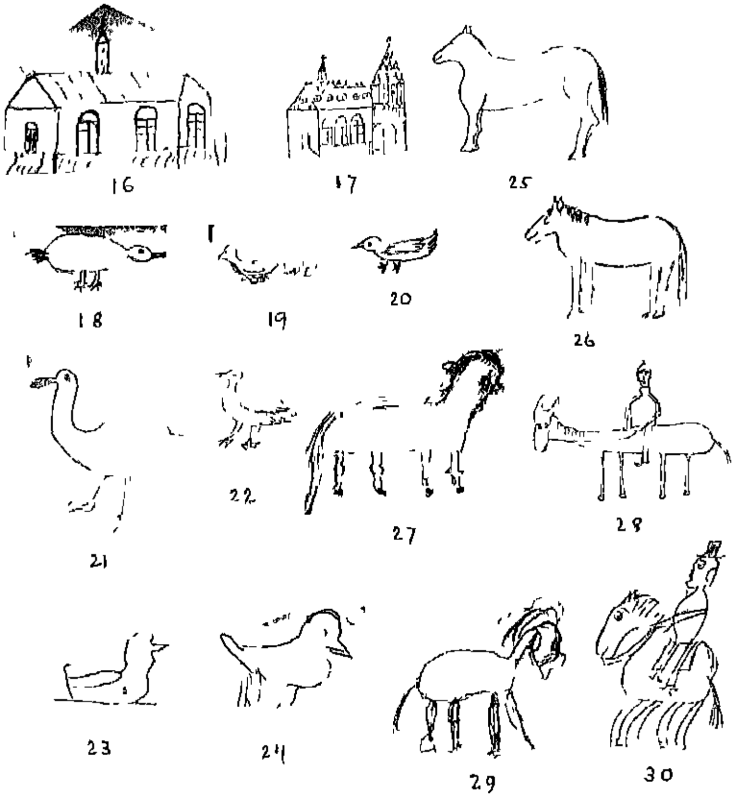

FIGURE 3

16 Drawn by adult
17 Drawn by 10-year-old child *
18 Drawn by adult
19 Drawn by 6-year-old child *
20 Drawn by adult
21 Drawn by adult
22 Drawn by 8-year-old child *
23 Drawn by 7-year-old child *
24 Drawn by adult
25 Drawn by 9-year-old child *
26 Drawn by adult
27 Drawn by adult
28 Drawn by 8-year-old child *
29 Drawn by adult
30 Drawn by 7-year-old child *
*From Georg Kerschensteiner.

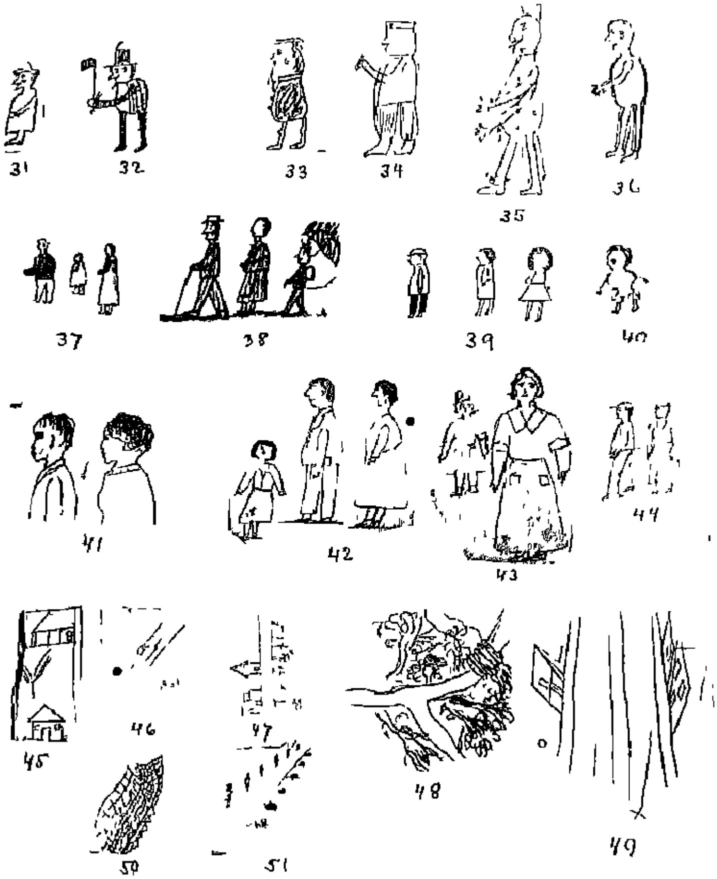

FIGURE 4

31 Drawn by adult
32. Drawn by 6-year-old child *
33 Drawn by adult.
34 Drawn by 7-year-old child *
35 Drawn by 8-year-old child *
36 Drawn by adult
37 Drawn by adult.
38. Drawn by 9-year-old child **
39 Drawn by adult
40. Drawn by adult.
41 Drawn by adult Chinese
42 Drawn by adult Negro
43 Drawn by adult Negro
44. Drawn by adult Negro.
45 Drawn by adult.
46 Drawn by 6-year-old child
47 Drawn by adult.
48 Drawn by adult
49. Drawn by adult
50. Drawn by adult
51. Drawn by adult

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*From G. Rouma: Le language graphique des enfants
**From Georg Kerschensteiner

somewhat true to form are shown in Figure 1, 5, Figure 2, 9. The drawings ranging lowest as to their presentation are shown in Figure 1, 6, 7; Figure 2, 10, 14; Figure 3, 27, 29; Figure 4, 31, 33, 36, 45, 47, 49. The main bulk of the drawings lies in between these two extremes, showing in the main, however, features of the schema, and therefore can be classified under that heading

Correctness of Drawing. A critical survey of the correctness of the objects drawn shows that in general the man-made objects are more correctly drawn than the living ones. The drawings of violins are an exception as many people have simply never handled one but have only seen it at a distance and even that not very frequently. Those persons who have owned or played a violin can always be recognized (and questioning showed this to be correct in every instance) because they draw the correct number of pegs, place them in fairly correct position, give the scroll a recognizable shape, and never forget to accentuate the sides

The drawings of a chair always show all the attributes of a chair and in fairly correct proportions Two-thirds of the presentations are given in correct perspective view

The drawings of a church are nearest to children's drawings of this object. It either gives a flat, one-sided view, a façade without body (Figure 2, 14, 15); or attempts to show two sides and fails (Figure 2, 10, 11, 12, 13) Sometimes three sides are shown in one front drawing, the sides being unfolded and laid flat in a plane. (Figure 3, 16, 17)

The common feature of all the drawings of living objects such as those of the duck, the horse, and of people is that one prominent part or detail (usually the head) of the animal or person, is shaped fairly true to appearance, while the rest is neglected and treated schematically By covering up one prominent part of the picture the remainder often turns out to be entirely unrecognizable.

In the case of the duck, the drawings, on the whole, do not display anything but the features of some composite bird Very seldom is the resemblance to the species achieved and then only in one or two important points (Figure 3, 18, 19, 20, 22, 23, 24).

The presentation of the horse by the adult differs in general from that of the child's in the make-up of the mental picture. The adult never puts a person on the horse unless requested to do so, while most children do not want to separate horse and rider (Figure 3, 28, 30) The horse is not only presented incorrectly as to type—it usually can be taken for a mule or an ass at its best—but the legs are shown with joints bent in the wrong direction (Figure 1, 3). The anatomical structure is an impossible one and would be wrong for any other four-legged mammal

The drawings of the "man, woman, child" show a more mature presentation of the face than the child achieves. Otherwise they are on the same level. Quite a number of drawings bear all the characteristics of the child's schema of the human form in their variations, for example, transparency of the figure (Figure 4, 35, 36), mixed profile (Figure 4, 31, 32), arms and legs in the form of pipes or soft tubes which end in five or less indentations for fingers (Figure 1, 1, 4), the profile of the head pointing one way, the main part of the body facing forward while the feet point oppositely to the profile.

"Flower" and "tree" are the two objects which bring more attempts of presentations true to appearance than of schemata. They show a good deal of incorrectness as to growth, in analogy with the anatomical mistakes displayed in the drawings of animals and persons, and the lack of knowledge as to the true form of man-made objects.

Drawings of the automobile, which is more familiar to most people than a horse, display no better knowledge of its construction than of other objects. (Compare the automobile in Figure 2, 8, to the horse made by the same man, who is a chauffeur by profession). The correctness of design, however, seems to vary among the groups tested according to the group's profession.

As to the last object, the perspective drawing of a street or country road, the failure is more obvious than in any of the other presentations. People with a maximum of educational background, such as scientists, engineers, etc., who are fully acquainted with the laws of perspective, fail to make use of this knowledge (Figure 1, 3; Figure 4, 49). Most adults remember that a road seems to become narrower the farther it extends, but they know little beyond this. Objects alongside the road are drawn as if they grew or were constructed not in an upright position, but at an angle of 45° to the vertical (Figure 4, 50, 51). In some cases they are even laid down flat or tipped over along the road as if their walls and windows were in one plane with the road (Figure 4, 47, 48). Table 2 shows

TABLE 2

	Number of			Percentage of		
	Men	Women	Both sexes	Both sexes	Men	Women
Number participating	74	96	170			
1 Non-converging lines for the street (no perspective at all)			72	42		
2 Turned down or slanting houses, or other objects along the road and non-converging lines	35	50	85	50	47	52
			13	7½		
3 Converging lines, but turned down objects			9	5½		
4. *Attempt at perspective through converging lines,* but the angle of convergency insufficient			19	11		
5 Attempt at perspective through faulty convergence and by diminishing the size of distant objects			25	15		
6 Correct perspective	9	3	12	7	12	3

the degrees of achievement of a true perspective view. Distinctly half of the subjects tested failed entirely In this failure more women than men were engaged. Only one out of every 14 persons was able to draw a correct picture and of these the majority were men

Correctness of Drawing in Relation to Race and Profession It has not been possible to observe any difference in the abilities of persons of different races. The scale of achievement of the eight Chinese who underwent the test is very much like that of white people. The negroes showed a few very poor drawings—comparable only to the drawings of children around six years old or younger, but so did some of the farmers. The weakest group among the persons tested was a small group of orthodox Jews, who had only had some odd bits of schooling in Hebrew schools in Eastern Europe As the group comprised only five people, one cannot draw any definite conclusions. Five other Jews were tested who had had normal American schooling, and they showed the average ability of any other person who underwent the test.

The profession, in general, as well as the schooling and background, do not seem to have much bearing on the outcome of the drawings. There are a few exceptions however, notably, the entire group of farmers who fell short in the drawing of the automobile and who made their street drawings quite primitive (rating under 1 and 2 in Table 2). The few other individuals, businessmen by profession, who rated rather poorly in the general performance, did, however, achieve a correct drawing of the automobile, since this is an object connected with their daily work. The women, as a group, made more correct drawings of flowers than did the men. The negroes, like the farmers, had great difficulties with the automobile. One member of this group, a chauffeur, made a comparatively poor automobile, but a well-outlined horse (Figure 2, 8). Living objects were easier for this group to draw. All their perspective achievements fall under 1 and 2, in Table 2, the only exception being a schoolteacher. A very curious fact worth mentioning is that the faces of the "man, woman, child" drawn by the negro group are exclusively white people's faces (Figure 4, 42, 43, 44), while the sketches made by the group of Chinese show Chinese characteristics as far as features are to be distinguished, but the bodies are clothed in European dress!

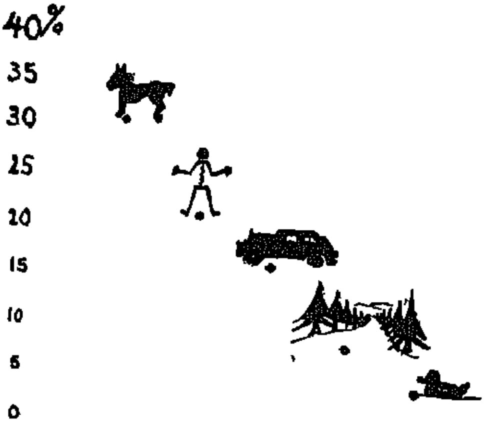

FIGURE 5
CURVE FOR "MOST DIFFICULT OBJECT"

The Questionnaire. Question 15 of the questionnaire: "Which object do you think was the most difficult to draw in this experiment?" shows the deep rooted and very salient difference in the conception of what "difficult" means to the adult and the child. According to the following table and curve the horse is considered to be the most difficult object. Horses, however, are an "easy" object for children. Even at a stage when they are still struggling to acquire the necessary graphic symbols for drawing a horse, their answer as to the difficulty of such a drawing is—none. Judging from what seems easy to children and difficult to adults, the curve could almost be reversed.

TABLE 3
"MOST DIFFICULT OBJECT" (IN PERCENTAGE)

Objects	Men	Women	Both
Horse	30	31	31
Man, woman, child	27	18	22
Automobile	12	20	17
Street	10	7	9
Duck	5	4	4½

Difficulty of the object in relation to profession is shown in Table 4. In this table it is interesting to notice that for the professionals,

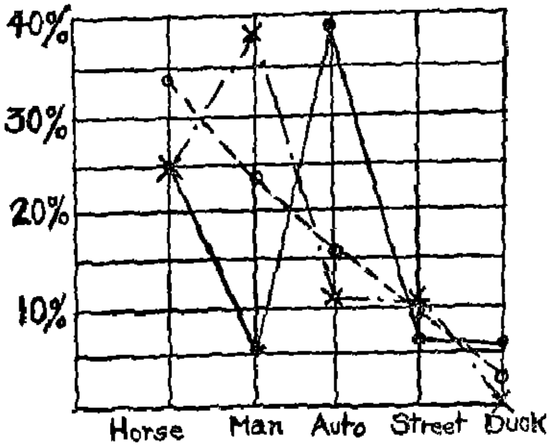

FIGURE 6

DIFFICULTY OF THE OBJECT IN RELATION TO RACE

O *White Race*
× *Yellow Race*
● *Negro Race*

as well as for business people, the horse is considered by far the most difficult object In contrast to this group the ratio of the number who considered the automobile to those who stated the horse to be the most difficult is 4 to 1 among farmers and 2 to 1 among housewives Although farmers do not think that the horse is a difficult object, yet their drawings of a horse are in no way better than their other objects It follows that familiarity with an object induces one to consider it easy to render, but the outcome of the drawing is none the better for that belief.

The answers to questions 13 and 14, "Are you deft with your hands in making things?" and "Are you awkward?" throw some light on the matter of manual ability and its relation to the correctness of the object and presentation in drawing This shows definitely that over half of the total number of people think themselves deft, over one-fourth consider their ability medium and only one-fifth think they are awkward.

Questions 17 and 18 were put so as to clarify the difference in the mental procedure when recalling and reproducing an object The

TABLE 4

		Violin	Chair	Church	Duck	Horse	Man, etc	Flower	Tree	Auto	Street
(74)	Professionals*	1	1	2	4	26	13		1	9	11
(33)	Business men	3		2	1	11	7			5	1
(23)	Skilled workers	3		1		10	3			2	3
(11)	Farmers				2	1	2	1		4	
(19)	Housewives					4	2	1		9	

*Scientists, teachers, engineers, musicians, journalists

TABLE 5

AFFIRMATIVE ANSWERS TO QUESTIONS 13, 14 (IN PERCENTAGE)

	Men	Women	Both
Question 13	43½	61½	52½
Question 14	20	21	20½

reconstructive mental attitude as described in question 18: "Did you try to remember how this object was made, of what parts it consisted, how long and wide those parts were, what was its moving mechanism and did you then reconstruct it accordingly?" is the process of recalling the object through conceptional and therefore more verbal than pictorial thinking This attitude occurs in 51 per cent of the cases. Question 17· "If you had a distinct picture in your mind of the object you were to draw, did you try to follow the shape of this picture instinctively with your hand just as you would when copying a picture or a real object?" is answered in the affirmative by those who have a pictorial memory and who attempt to copy from this mental picture. This method was followed by 40 per cent of the subjects tested, while nine per cent used a combination of both methods These percentage rates remain the same if calculated for each sex separately.

We see, therefore, that only 40 per cent claim to have retraced the object from visual memory alone, 9 per cent use a combination of visual and constructive memory, whereas 51 per cent rely entirely on logically interlinked yet non-visual knowledge.

Two other questions are of great interest, questions 6 and 7· "Did you draw, when a child, at home (for the fun of it)?" and "Did you draw in school?" Only half of the adults drew as children "for the fun of it", 73½ per cent had had some kind of instruction at school In classifying the type of instruction given at the time Table 6 was obtained. Those who had drawn from life

TABLE 6

	(In percentage) Men	Women	Both
Copywork	63½	78	70½
Inanimate objects (geometric forms)	71	61	66
Flowers	51	64	57½
Living things	33	31	32
From memory	26½	21½	24

mentioned that it had not been often, and drawings from memory were made "once in a long while."

INTERPRETATION

The Lack of Manual Ability. The lack of manual ability seems to be a small factor if one considers the answers in the questionnaire which portray the subjective impression of every individual Objectively considered, the hand of the adult is trained in all kinds of skilled work which involves a good coordination, mobility, and agility. Writing, a most complicated combination of lines, has been mastered so as to become automatic In contrast to the child who, in his schematic stage of graphic presentation, is unable to take advantage of the opportunity of seeing a model, the adult improves his drawings immediately and considerably when given a model of the object he is supposed to draw. The hand is able to follow the shape he perceives as long as this shape stays before his eyes.

Lack of Memory. The objects which were drawn were all familiar to the persons who were tested Most of them were certain that they could conjure a very clear mental picture of the object Some of them described how they could visualize one part of it, but did not remember other parts when it came to the actual drawing.

The drawings, the questionnaire, and the individual answers to questions asked, as well as the observations made during the act of drawing, show that the inability to present familiar objects correctly—not artistically!—may be traced to the following factors.

a Blurred mental pictures. The person with a blurred mental image usually is unaware that his mental picture lacks precision. He believes to have a distinctly shaped outline of the object because he knows with certainty that he will *recognize* it at any time it is shown to him and he therefore concludes that he can produce it himself at will.

b. Clear but fragmentary pictures The person in question is aware of a clear but fragmentary picture but is unable to connect the parts together in a sensible manner He, therefore, tries to bridge the gap in his memory by a guess which spoils the partly correct presentation and at the same time confuses his formerly clear memory of the parts known to him.

c. Lack of real knowledge of the object. The mental picture is not such as to enable the person to reconstruct the object he is *trying to remember* by assembling the different parts, putting them together at the correct joints, and applying the moving mechanism which is peculiar and necessary to this object.

In analyzing the process of graphic presentation it may be described as dependent on the ability to know an object in its proper dimensions and proportions, to distinguish clearly between characteristic parts of the object and parts of negligible importance, to point out the main and outstanding feature of this object, and to bring about a certain *coordination* of the analyzing procedure of the mind and the synthetic operation of the hand. This process, therefore, is based on the outline and also on the color aspect of the object and on a memory capable of retaining just such an aspect

The mnematic picture, however, does not seem to be an outline or color picture only, with emphasis on the various features and their correlation—it is "sensed-mixed" Instead of being purely visual, the mnematic picture seems to be connected with the other senses, and is *a mixture of visual, tactile, auditory, and olfactory* sensations. Those sensory memories interlink and form a whole. When such a mnematic whole is brought to consciousness a sorting of the different sensations is almost impossible, the interlinkage of the parts which form the whole object is *not* recalled, and this "sensed-mixed" memory blurs the outline of the picture, causing gaps and holes

Another difficulty for the graphic presentation by memory arises through the habit of thinking in form of abstract conceptions The memory of an image itself is usually permeated with abstract descriptive words and therefore we are not aware that the actual image has not been retained.[1]

The incorrectness of the drawing seems to be due to the inability to disentangle the interlinked sense impressions and to pick out and connect that which may be translated into lines (and colors) on paper. The schematic effect of the drawing points to a return to childhood memories which seem to stand out clearer than later ones, although several impressions supercede each other and settle down to a definite mental picture. These memories seem to be associated with the child-like manner of presenting them. They are, to some extent, "fixed." There is no doubt, however, that the child masters graphic presentation and verbal presentation equally well at the age when his pictures are schematic. The child, in general, undoubtedly has strong eidetic characteristics which are bound to influence his memory and the character of his recall. At the time when he uses the schema his eidetic faculties are still an element to be counted on They influence his mnematic pictures when drawing The manner of training which is mainly verbal and conceptual influences any superimposed mnematic picture of the child and is apt to render it less visual

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[1] We would like to emphasize the fact that *this process is not limited to visual apperception only but applies equally well to the auditory memory* as required in music It seems to be in general one of the most *serious* obstacles to be overcome in the common learning habits

With advancing education verbal and conceptional thinking diminish the wish as well as the ability to present objects graphically. Graphic presentation stops or becomes an aesthetic element confined to the drawing or painting of some flowers or other objects, done after a certain—mostly copied—code. When an adult is asked to draw an object, the mnematic picture conjured goes back to a mental picture stored away in childhood. Having stopped in his stage of graphic development when at the schematic stage, the schema seems the only feasible way for expression This effect is strengthened because the memory reaches back to this primary stage of childhood and also because this way of drawing then became habitual, very much as handwriting develops until it becomes more or less automatic and can hardly be altered.

CONCLUSION

The fact that the adult, although mature in most of his ways of expression, has not matured in graphic expression is due to onesided development of conceptions by verbal training If graphic expression is to be part of the general education—as art training suggests—the training for and through graphic expression has to take these facts into basic consideration for any system or plan of teaching to be successful

Along with the art teaching, the nature of which is fundamentally aesthetic, a teaching in graphic expression as such is desirable. Such a teaching in graphic expression may lead to a form which satisfies aesthetic demands, and therefore approaches art; yet the aesthetic factor is of minor importance. The main goal of this branch of teaching should be the strengthening and development of the visual memory, and the emphasizing of the concrete aspect of things together with the usual abstract way of presentation Several subject matters are of an essentially concrete nature as for example botany, zoology, or geography. The usual means of conveying these matters is by verbal description, together with a more or less rich picture material, which means that the part of memory necessary for recognition only is being developed.

In analyzing the results we see that the graphic presentation tends to be more correct for those persons who are also able to reconstruct their material logically. Very often we find a tendency in the teaching of drawing to over-emphasize the intuitive side of the process. While this may lead to a better artistic expression, it does not develop the visual abilities as well as the analytical process does. The training in drawing is important as far as general education is concerned because of the possibility of the artistic development, but still more so because it leads to the retention in memory of the correct orientation of shapes and forms in space. The step from a first impression to recognizing this impression is a short one compared to the many steps necessary to arrive from recognition to pictorial presentation of this impression.

The kind of memory necessary for recognition only is deceiving as far as recalling the actual knowledge of the object is concerned. Very few characteristics of an object suffice for recognition Sometimes a single one will be enough Yet the person who recognizes the object imagines that he has accurate and detailed memory of the object. Smell, hearing, and especially touch are parts of the recognition. The attempt to discriminate and sort out the visual part of the memory would necessarily lead to a general heightening and sharpening of the analytical and synthetical faculties

Assuming that the goal of education is not an accumulation of specialized knowledge, but that special knowledge is only a means to develop the abilities of comprehension and thinking, a teaching in graphic expression will help toward this end and lead to a more mature and full use of the senses

SUMMARY

The average adult, mature in his verbal and written expression, fails entirely when drawing. This may be well known but has not received the attention it deserves. Ten objects have been used to show this fact, drawn by 170 adults. Comparison with the draw-

ings of the same objects made by school children showed a strong likeness of the adult's to those of the child's presentation Most of the adults' drawings belong to the schematic stage of children's drawings. The differences of race, profession, and general background reveal only minor differences

The questionnaire connected with the experiment shows that a larger percentage of persons tries to reconstruct logically the object from memory

Lack of manual ability does not seem to be the important factor of the failure The mnematic picture is unfit for graphic expression, being by no means a purely visual one; instead the memory picture is "sensed-mixed," a mixture of visual, tactile, auditory, and olfactory sensations These sensory memories interlink and form a whole

The inability to disentangle the interlinked sense impressions leads to incorrectness, whereas the fact that most first impressions are settled in childhood and seem to be associated with the childlike (schematic) presentation of that stage of development accounts for the character of the presentation.

Teaching by means of graphic presentation (not only verbally) is judged to help the strengthening of visual memory as well as to develop discrimination, analytical and synthetical, for concrete subjects

It is a pleasure to thank Dr Harriet O'Shea of the Education Department for her continued interest in this work, for many valuable discussions, and for her help in procuring the material necessary for this research.

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MENTAL DEVELOPMENT OF CHILDREN IN FOSTER HOMES*[1]

From the Iowa Child Welfare Research Station at the State University of Iowa

HAROLD M SKEELS

A study of the mental development of Iowa children placed in foster homes in that state is being carried on cooperatively by the Iowa Child Welfare Research Station and the Bureau of Child Welfare. The subjects of the study are children from the lower social, economic, and educational levels who have been placed in average and superior foster homes sometime during the period from two months to five years of age As set up, the study will comprise mental measurements on these children over a long period of time, including annual tests during the preschool ages and three or four tests during the elementary school years.

The study as now presented is the first unit of this intended long-time investigation and includes only children who were placed in foster homes under six months of age. From this it may be seen that these children have therefore experienced essentially only the environment of the foster homes.

It may be stated that this study was not set up with any preconceived ideas as to the effect of the environment on growth of intelligence. It grew, instead, out of the regular clinical program The Bureau of Child Welfare requires that a child remain in a foster

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[1]The writer wishes to express deep appreciation to Dr. Mae Habenicht, Superintendent of the Bureau of Child Welfare, for approving and encouraging such a study of foster children, and for her helpful suggestions; to the Iowa Board of Control of State Institutions which has at all times cooperated in making possible research studies of state wards, to Mr H A. Mitchell, Superintendent of the Iowa Soldiers' Orphans' Home from which the children reported in this study were placed; to Miss Marie Skodak, assistant psychologist of the Board of Control, who made a number of the examinations and who rendered material assistance in setting up this study; and to Dr. George D Stoddard, Director of the Iowa Child Welfare Research Station, who has made possible this study

home at least 12 months before adoption is permitted. On February 1, 1934, a policy was established whereby no child can be adopted until a psychological examination has been made.

Examiners visiting foster homes for the purpose of making these psychological examinations would expect to find frequent cases of retarded children, judging from the histories of the true parents. When these examinations repeatedly failed to show such retardation, it seemed important that a more extended study on a research basis be made. *Data have therefore been compiled on all children (under six months of age at the time of original placement) for whom application for adoption was made during the year February 1, 1934 to February 1, 1935, a total of 73.*

DESCRIPTION OF THE IOWA FOSTER HOME PLACEMENT PROGRAM

Children available for foster homes are placed through three general avenues including relatives, private placing agencies, and the Bureau of Child Welfare of the Board of Control of State Institutions. Those of superior and average inheritance more frequently are kept by relatives or are committed to private agencies while a fewer children with average or somewhat above average inheritance are committed to the state orphanages, the greater percentage of cases handled through the Bureau of Child Welfare come from the lower social, economic, and educational levels of society. It is with this latter group that this study deals. Although the present program *includes careful selection* of children for placement, not only withholding those with questionable histories and low performance, but also attempting to match the ability levels with opportunities *offered by the homes, such was not the case when placements of the* children included in this study were made. At that time infants were customarily placed who were medically approved and who did not show gross physical defects. Little, *if any,* consideration was given to other factors of fitness for placement.

Examination of the data in Table 1 shows that selective placement as an influencing factor may be ruled out. Comparisons of placements in relation to occupational status of foster fathers with reference to such factors as true mother's IQ, true mother's education, true father's occupation, and true father's education show no relationships. If a positive relationship existed, the scattergrams would show a diagonal line of central tendency. That is, the children

TABLE 1

DISTRIBUTION OF CHILD PLACEMENTS IN RELATION TO OCCUPATIONAL STATUS OF FOSTER FATHER AND FACTORS PERTAINING TO TRUE PARENTS

Factors relating to true parents	Paternal occupational levels of foster home placements							
	I	II	III	IV	V	VI	VII	Total
			Mother's IQ					
90 to 109 IQ	2	1	7	2	1	1		14
80 to 89 IQ	1		2	5	2			10
70 to 79 IQ			4	1	2	1	1	9
Below 70 IQ	2		2		1	1		6
Total	5	1	15	8	6	3	1	39
			Mother's education*					
6th grade		1	1		2	1		5
7th grade	2	1	4	2		1		10
8th grade		1	5	8	3			17
9th grade	2		2	1	1			6
10th grade	1	1	2		1		1	6
11th grade	1		4	1	3			9
12th grade	1		5	3	3	1		13
13th grade			2					2
14th grade								0
15th grade			1					1
Total	7	4	26	15	13	3	1	69
			Father's occupational group					
Group I								0
Group II			1					1
Group III	1		3					4
Group IV		1				1		2
Group V	1		6	1	3	1		12
Group VI	1	1	1	5	2			10
Group VII	2	1	10	6	3	2		24
Total	5	3	21	12	8	4		53
			Father's education*					
6th grade			2		1			3
7th grade				2				2
8th grade	1		1	4	3			9
9th grade	1		1	1				3
10th grade	1			1	2			4
11th grade	1							1
12th grade	1	1	8	3	1	1		15
13th grade	1		3					4
14th grade			1					1
Total	6	1	16	11	7	1		42

*Grade completed

from fathers of the higher occupational levels, for example, would tend to be placed more frequently in foster homes of the higher occupational levels and vice versa. The data show that such is not the case (Table 1) As many children from mothers with IQ's below 70 have been placed in the higher occupational levels of foster homes as have been placed in the homes of lower levels. Similarly, other comparisons of education of true mothers and true fathers show a lack of selection in placement

EDUCATIONAL, ECONOMIC, AND VOCATIONAL STATUS OF TRUE PARENTS

Educational attainment of true mothers in terms of grade completion shows a mean of 9.4 school grades finished, 21.8 per cent had less than an eighth grade education and only 4.4 per cent had any college work at all (Table 2) None of the mothers were college graduates (Table 3).

Intelligence tests (Stanford-Binet) were available on 39 of the 73 mothers. The mean IQ for this group of 39 was 83.8 with a standard deviation of 12.3. The median falls at 86.5 While only 10 per cent of these 39 mothers had IQ's above 100, 38 per cent had IQ's below 80. Since the educational and socio-economic status of these 39 mothers did not differ from the other mothers included in the group of 73, it is felt that this level of intelligence may be taken as representative of the group as a whole.

The true fathers' education is not materially higher than that of the true mothers—the mean grade completed by the fathers being 10.2 as against 9.4 for the mothers (Table 2). None of the fathers were college graduates, only 11.9 per cent had any college work and 10.2 per cent had less than an eighth-grade education (Table 3)

Occupational status of the true fathers has been measured using the classification of occupations of employed males in the United States from the report of the Fourteenth Census of the United States, Volume 4, 1920 [cited by Goodenough (3, Appendix, pp. 501-502)]. This report classifies occupations in seven groups grading downward from one to seven:

Group	Occupation
I	Professional
II	Semi-professional and managerial
III	Clerical, skilled trades, and retail business
IV	Farmers
V	Semi-skilled occupations, minor clerical positions, and minor business
VI	Slightly skilled trades and other occupations requiring little training or ability
VII	Day laborers of all classes

Factors	True parents				Foster parents			
	Number	Mean	Standard deviation	Median	Number	Mean	Standard deviation	Median
Occupational status of fathers (U S Census)	54	5 8	1 34	6	73	3 5	1 37	3
Education of fathers (School grade completed)	42	10 2	2.25	10	71	11 5	2 87	12
Education of mothers (School grade completed)	69	9 4	2 15	9	71	11 7	2 67	12
Mid-parent education (School grade completed)	42	9 8	1 90	10	70	11 6	2 61	12

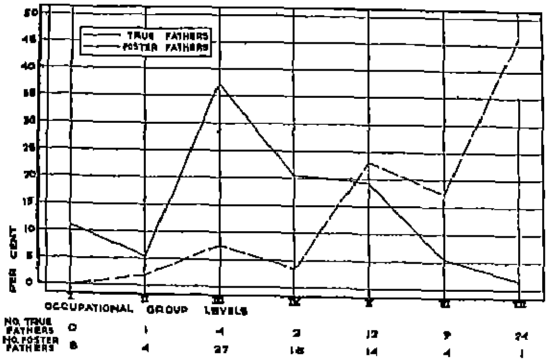
TABLE 3
EDUCATION OF TRUE AND FOSTER PARENTS

Educational level (School grade completed)	True parents				Foster parents			
	Fathers		Mothers		Fathers		Mothers	
	Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent
Graduate work (one or more years)					5	7 0		
College graduate					9	12 7	9	12 7
Some college work (one or more years)	5	11 9	3	4 4	9	12 7	20	28 2
High school graduate	15	35.7	13	18 8	16	22 5	15	21 1
Some high school work (one or more years)	8	19 1	21	30 4	9	12 7	10	14 0
Grade school graduate	9	21 4	17	24 6	23	32 4	17	24 0
Seventh grade or below	5	11 9	15	21 8				

On such a classification of occupations true fathers show a mean occupational status of 5.8 (Table 2). Forty-six per cent of true fathers classed in the lowest level, day laborers. As shown in the following tabulation, only 13 per cent classed above Group V, that of semi-skilled occupations (Figure 1).

Group	True fathers		Foster fathers	
	Number	Per cent	Number	Per cent
I			8	11.0
II	1	2.0	4	5.5
III	4	7.7	27	37.0
IV	2	3.7	15	20.5
V	12	23.1	14	19.2
VI	9	17.3	4	5.5
VII	24	46.2	1	1.3

It will be seen from these data that the 73 children reported in this study came from rather low educational, occupational, and socio-economic levels of society. In spite of the fact that 65 of these 73 children were illegitimate, it is evident from these comparisons that the true fathers were only about one grade higher than the mothers, *with occupational levels largely day laborers and slightly skilled* laborers. A qualitative analysis of social histories seems to justify the conclusion that within these educational and occupational classifications of true parents, the individuals represent the lower levels



DISTRIBUTION OF OCCUPATIONAL
LEVELS OF TRUE AND FOSTER FATHERS

FIGURE 1

in such groups Many of these fathers and mothers dropped out of school because of having reached their limit of achievement and in no sense of the word represent the averages of their grade placements. Similarly, not only were 86 per cent of the fathers of the lowest three occupational levels, but a large percentage were not self-supporting and were known to relief agencies over a long period of time. While data are not adequate for a quantitative analysis of grandparents, inspection of those histories which give such information show them to be from similarly low socio-economic levels. Children were committed to the state because neither the mother nor her relatives were economically able to assume responsibility for the child.

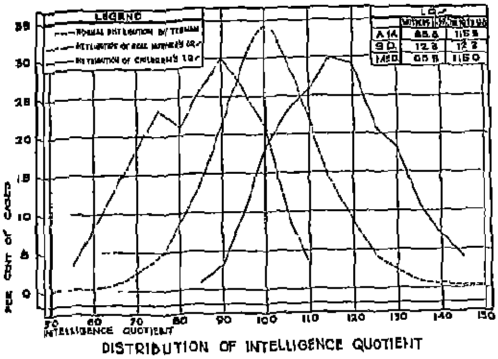
MENTAL DEVELOPMENT OF THE FOSTER CHILDREN

Mental development can be reported at this time only in terms of the first mental test of the consecutive growth series At the present time the second series of tests is just being started after an interval of a year to a year and one-half from the first examinations. While these first examinations were imperative at young ages from the clinical requirement in completing adoption, it was felt equally important, from the research standpoint (in a study of environmental influences as related to growth of intelligence), to have records of mental development during the preschool years before the leveling effects of attendance in the public schools.

As standard measures of intelligence the Kuhlmann and Stanford Revisions of the Binet Scale have been used Children under three and one-half years of age at the time of examination were given the Kuhlmann Revision and those over that age the Stanford Revision. The mean chronological age at the time of placement was 2.5 months with no child over six months of age. At the time of examination the mean chronological age was 24 4 with a standard deviation of 14.2, mean length of residence in the foster homes was 21.9 months.

	Number	Mean	Standard deviation	Median
Chronological age in months at time of placement	73	2 5	1.6	2.0
Chronological age in months at time of examination	73	24 4	14 2	18 8
Mental age in months at time of examination	73	27 7	15 0	21.6

Results indicate the mean IQ of the group to be 115.3. Of the 73 children, 98.6 per cent class as normal or above. Only one child was below average and that at the dull normal level. Sixty-five per cent classed as of superior intelligence, that is with IQ's of 110 or above. Thirty-four per cent had IQ's of 120 or above (Figure 2).



CHILDREN PLACED IN FOSTER HOMES UNDER SIX MONTHS

FIGURE 2

Dickson (1) studied a group of 150 first-grade children in their own homes. They were grouped according to different paternal *occupational levels* using the Taussig Scale. Dickson found a mean IQ of 112.5 for classes I and II (professional and business) combined, and a mean IQ of 82.5 for classes V and VI (farmers and unskilled laborers) combined. The children reported in this study whose fathers would compare favorably with Dickson's groups V and VI do not give that expectancy in level of intelligence, but rather compare favorably with the findings on children from paternal occupational Groups I and II.

Goodenough (4, p 45), using the Kuhlmann Binet in a study of two-, three-, and four-year-old children in their own homes, reports for the different paternal *occupational levels* mean IQ's from Group I as 116 1, Group II as 111 7, and Group VI as 96 0 While the level of intelligence for children from the lower occupational levels is somewhat higher than that reported by Dickson (1) when he used the Stanford scale on children somewhat older, yet the levels for the higher occupational groups are comparable. Here again the foster home children in the present study are as high as those reported by Goodenough for children from occupational Groups I and II.

In connection with a study of the mental development of children in relation to preschool attendance, Wellman (5) found that a group of 591 children whose fathers had a mean occupational level of 1.6 showed a mean IQ of 112 at the time of initial enrollment. Mean IQ for children reported in the present study is comparable to those reported by these other investigators for occupational levels I and II.

In the following tabulation data have been analyzed further in relation to type of test, age at time of test, sex differences, and variations in results obtained by different examiners. Sixty-one children (under three and one-half years of age at the time of examination) given the Kuhlmann-Binet had a mean IQ of 116.0, and 12 children (over three and one-half years) given the Stanford had a mean IQ of 111.6, showing those given the Stanford to have a mean IQ 4.4 points lower.

		Intelligence quotients		
Factors studied	Number	Mean	Standard deviation	Median
Entire group	73	115.3	12.2	115.0
Kuhlmann-Binet examinations	61	116.0	12.0	116.0
Stanford-Binet examinations	12	111.6	12.9	114.0
Children below 24 months at examination	49	117.8	13.9	118.0
Children above 24 months at examination	24	111.3	12.5	111.0
Children above 36 months at examination	13	107.8	12.9	105.0
Boys	32	115.4	13.2	116.0
Girls	41	115.3	11.4	115.0
Children examined by examiner No. 1	34	116.0	12.6	116.0
Children examined by examiner No. 2	37	115.1	11.6	113.0

When divided by age levels, 49 children under 24 months at the time of examination showed a mean IQ of 117 8; 24 children above 24 months, 111 3; and 13 children above 35 months, 107.8. At this stage of the study, with so few cases at the higher age levels, it would seem inadvisable to draw conclusions as to this difference between ages Many factors may be operating to cause this, such as faulty standardization of the tests, chance differences in samplings at the different ages, differences in parent-child relationships between those that apply for adoption at the end of 12 months and those that wait for four years, differences in efficiency of mental stimulation offered by the home at different child age levels, etc

No sex differences were shown, the 32 boys having a mean IQ of 115 4 and the 41 girls a mean IQ of 115 4.

The question of a possible difference in test results between examiners was considered with the thought that perhaps there were differences in leniency in scoring. All examinations were made by two trained examiners, Miss Skodak, assistant psychologist of the Iowa State Board of Control, and by the writer of this report The examiners received their training at different schools and made all of the examinations separately. Differences were not found between the results of the two examiners. Thirty-four children tested by the first examiner showed a mean IQ of 116 0, while 37 tested by the second examiner had a mean IQ of 115 1.

EDUCATIONAL, SOCIO-ECONOMIC, AND VOCATIONAL STATUS OF FOSTER PARENTS

The educational level of foster parents was, of course, materially higher than that of true parents, although differences are not great in terms of central tendencies (Table 2) Foster mothers had a grade completion mean of 11 7, which was 2 3 grades higher than that of the true mothers. Foster fathers with a mean grade completed of 11 5 were 1.3 grades higher than true fathers. Extremes in educational differences were more marked (Table 3). Whereas only 11.9 per cent of true fathers took some college work, with none graduating, 32 4 per cent of the foster fathers had had some college work, 12.7 per cent were college graduates, and seven per cent had taken graduate work. At the other end of the scale, while 11.9 per cent of the true fathers and 21.8 per cent of the true mothers had

had less than eighth grade schooling, no foster father or mother had dropped out of school before completing the eighth grade.

More marked differences were shown between true and foster paternal occupations (Table 2 and Figure 1) Using the same occupational classifications, the mean for foster fathers was 3.5 as against 5.8 for true fathers, showing a difference of 2.3 in mean level in favor of the foster group In contrast with the 63 per cent of the true fathers who classed below Group V, less than seven per cent of the foster fathers so rated. While only 13 4 per cent of the true fathers placed in the first four occupational groups, 74 per cent of the foster fathers were so classified (Tabulation p. 96) and Figure 1).

Qualitative differences between true and foster parents within educational and occupational group levels make for an even greater spread than is shown by group classification levels While it was stated that true parents represented a weighting on the lower levels within divisions, it is probably equally apparent that foster parents fall in the upper range within units of comparison. For example, the brick layer whose home is being considered for the placement of a child must not only have an acceptable occupation but must be successful in this position Success is thought of in terms of his management of finances being such that he is not heavily in debt, he has satisfactorily maintained a home over a period of years, and he is able financially to take on the additional obligation of one more member in the family. In addition, his social adjustment in the community must be satisfactory. Favorable references must be furnished by the banker, minister, doctor, and at least one other, favorably recommending the placement of a child in the home Meeting all these requirements would of necessity result in a definite selection upward within these more general group classifications.

MENTAL DEVELOPMENT OF CHILDREN IN RELATION TO FACTORS PERTAINNG TO TRUE AND FOSTER PARENTS

Comparative correlations between children's IQ's and factors relating to true and foster parents, including IQ of true mothers and education of true and foster parents, show little relationship as measured by correlation techniques. A zero correlation (09±.11) was obtained between true mothers' IQ's and children's IQ's The highest correlation was with mid-parent education of true parents and

	True parents			Foster parents		
	Number	r	Probable error	Number	r	Probable error
Education of father	42	+ 23	±.10	72	+ 01	± 08
Education of mother	69	+.13	±.06	71	— 10	± 08
Mid-parent education	42	+ 29	± 10	70	— 04	±.08
Mother's IQ	39	+ 09	± 11			

child's IQ which was *only .29±.10. The lowest correlation was* with *education of foster mothers,* which was —.10±.08

In *making further* comparisons of children's IQ's as *relating* to true parents, a mean IQ of 115 5 was obtained for all children whose true mothers' IQ's fell at the borderline or feebleminded level (below 80). The mean IQ of this group of children from the mothers of lower IQ's was only *one point lower than that* of the entire group of children. These findings are higher than those of Freeman (2) in his study of foster children from defective parents. He found a mean IQ of 95 1 on 86 children who had one defective parent and *who had been removed from their own homes before* the age of five.

Factors relating to true parents	Number	IQ's of children Mean	Standard deviation	Median
IQ's of mothers *(Mean IQ = 83.8)*	*39*	*116.7*	*13.0*	*118 0*
Mothers with IQ's below 80 (Mean IQ = 70 7)	*15*	*115 5*	*12.3*	*110 0*
Fathers of occupational levels IV, V, VI, and VII	48	114 9	12 5	115 0
Fathers of occupational levels VI and VII inclusive	33	115 4	12 9	116 0
Fathers of occupational levels VI and VII, and mothers with grade school education or lower	17	111 2	11 9	111.0

In the present study children whose true fathers classed in the two lowest occupational groups showed a mean IQ within one point of the total group. Taking the children with low inheritance on both sides, that is with fathers of occupational groups VI and VII and with mothers of eighth-grade education or less, the mean IQ was 111.2, *or only* 4.1 *points lower than for the entire* group.

Comparisons of children's intelligence with the occupational levels of foster fathers shows an absence of relationship for children under two years of age. As age increases there appears to be a tendency for positive relationship (Table 4). Combining children from

TABLE 4

MEANS, STANDARD DEVIATIONS, AND MEDIANS OF CHILDREN'S IQ'S IN RELATION TO OCCUPATIONAL LEVELS OF FOSTER FATHERS

Occupational levels of foster fathers	Number	Mean age, months	Children IQ's Mean	Children IQ's Standard deviation	Children IQ's Median
Groups I, II, III combined (all children)	39	26.4	115.7	11.4	114.0
Groups IV, V, VI, VII combined (all children)	34	22.2	114.9	13.2	116.5
Groups I, II, III combined (children below 24 months)	24	16.3	117.1	11.7	114.5
Groups IV, V, VI, VII combined (children below 24 months)	26	16.9	118.3	11.5	119.5
Groups I, II, III combined (children above 24 months)	15	42.5	113.5	10.2	113.0
Groups IV, V, VI, VII combined (children above 24 months)	8	38.4	103.7	12.3	102.0
Groups I, II, III combined (children above 36 months)	9	52.0	112.1	12.5	109.0
Groups IV, V, VI, VII combined (children above 36 months)	4	48.8	98.3	7.3	97.5

the higher occupational levels including groups I, II, and III, and comparing them with those of the lower occupational levels, groups IV, V, VI, and VII, for children under 24 months (chronological ages between groups being comparable) gave mean IQ's of 117.1 and 118.3 respectively. For children over 24 months a difference of 10 points' mean IQ was obtained in favor of the higher occupational levels. When only those children who were over 36 months at the time of examination were compared, the mean IQ for higher occupational levels was 112.1 as against 98.3 for the lower, showing a difference of 13 8 in favor of the higher occupational levels. The numbers at these higher ages are so few as to make it impossible to draw any conclusions as to an increased relationship between foster-paternal occupational levels and differences in intelligence with increase in the age of the child However, this tendency may be worthy of further consideration.

Although correlation techniques show little relationship with education or occupational status of either true or foster parents, the fact yet remains that the level of intelligence of these children is higher than would be expected for children whose fathers were of comparable occupational levels. In fact, these children compare favorably with those from the highest occupational levels, Groups I and II.

The question may be asked as to why these children class higher than might be expected from the educational and occupational status of the foster parents, which in itself is materially higher than that of the true parents. Data obtained to date do not permit drawing conclusions on this point, although some inferences may be cited as possible factors. It has been previously indicated that the foster parents represent a selection upward within general classifications, such as educational achievement and paternal occupational status.

It is quite possible that there are other factors, which we are unable to measure quantitatively, that affect the mental development of the child to a much greater degree than differences of educational and occupational levels. Parent-child relationship within gross group classifications may be of significant importance.

Then too, it must be remembered that these foster parents are vitally interested in having a child in the home or they would not go to all the effort necessary to bring this about. With this great interest, such parents may take greater cognizance of the need for play equipment, books, and nature study trips than do true parents who suddenly find themselves confronted with the problem of rearing a child for whom little preparation had been made. Such parents may also be more willing to answer questions put by the two-year-old and thus encourage that habit and method of quest for knowledge, whereas the ordinary parent may more frequently discourage the child in similar situations.

It is quite possible that a home of rather low educational and occupational level may be highly stimulating to the mental development of a two-year-old but materially less stimulating to a four-year-old child It is hoped, as the study progresses and repeated measurements on the same children are obtained, that further information may be secured concerning some of these factors

SUMMARY

As the first unit of a study of the mental development of children in foster homes, results have been reported on 73 children placed under six months of age. Mental tests were obtained on all children 12 to 60 months after placement. Histories of both true and foster parents, including educational attainment, occupational status, and economic security have been evaluated.

Findings to date seem to indicate the following·

1. The mean level of intelligence of these children is higher than would be expected for children coming from the educational, socio-economic, and occupational level represented by the true parents
2 The mental level of these children compares favorably with that reported by Goodenough, Wellman, and Dickson for children of similar age from superior occupational levels, Groups I and II.
3. A zero correlation was obtained between true mother's IQ and child's IQ
4. While there is little relationship between children's IQ's and foster fathers' occupational status, the few cases at the older preschool ages indicate the possibility of a positive relationship as age of the child increases

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CONDITIONED RESPONSES IN THE WHITE RAT: II. CONDITIONED RESPONSES BASED UPON SHOCK TO THE FORELEG*

From the Psychological Laboratory of Brown University

H. SCHLOSBERG

INTRODUCTION

In the first paper of this series (19), the reactions of white rats in a simple shock conditioning situation were described, together with the effects of certain variations of this situation on the rate and extent of conditioning During the study previously reported, the shock was delivered near the end of the tail Under optimal conditions, it was relatively easy to establish conditioned breathing reactions, but the tail was somewhat more refractory to conditioning. The difficulty encountered in establishing the conditioned tail withdrawal and the general instability of the response, once established, were surprising, in light of current conceptions of the conditioned response. It was thought that these results might be peculiar to the tail, for this member is scarcely a manipulative organ in the rat. Therefore it was decided to carry out a comparable study, using the foreleg as the site of the shock and recording its movements, rather than those of the tail The present paper reports such a study.[1]

APPARATUS

The only fundamental modifications in the apparatus, as described in the first paper of this series, were the construction of a new holder and a change in the electrodes In the original apparatus, the animal was held in a crouching position in a cradle-like structure ("original

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[1] Some reference has been made to this study in a footnote to the first paper of the series and during two reports (18, 20). The study was initiated by Mr W Pfouts, at the writer's suggestion Unfortunately Mr Pfouts found it necessary to discontinue his work during the preliminary experimentation. Since he used a different strain of animals, his results will be reserved for a later paper.

holder" in Figure 1). The legs were therefore inaccessible The holder used in the present experiments is labelled "present holder" in Figure 1. It consisted essentially of a block of wood 3½ x 6½ x 1½ inches with a trough-shaped metal support for the animal's body. The rat was held securely in this support by a sleeve that passed around its body and closed with laces along the midline of the back. The head was supported by the forward end of the block which was raised ¾ inch above the body support and hollowed out into a trough A thong passed over the animal's neck, just behind the occiput and held the head securely. Finally, the three unstimulated legs were loosely fastened by thongs, attached to clips on the baseboard so that the animal straddled the block If properly adjusted, these fastenings usually held the rat securely. In general, it may be said that the holder was less satisfactory than the one used during the conditioning of the tail reactions since it led to somewhat greater struggling.

To the right foreleg was attached a small noose made of a wick-like cloth tubing When moistened, this served as the active electrode. Clipped to the noose was a thread which passed down through an agate guide on the baseboard, over a short-circuiting contact (*SC*) and then to the recording system. The lever in this system increased the reactions on the record to three times their actual extent. Under the animal was a rubber sac which served as a pneumograph. Covering the sac was a piece of thick, absorbent cloth that protected it. When moistened with Ringer's solution, this cloth served as the "indifferent" electrode, coming in close contact with about 25 square centimeters of the animal's ventral surface

Mounted on a standard two inches in front of the animal was a miniature bulb and reflector (the latter not shown in Figure 1) A bright metal hood was placed over the front end of the holder during actual experimentation. This hood served to increase the effectiveness of the light as well as to eliminate extraneous visual cues

For convenience the new holder was mounted on legs so that it could be placed directly above the holder used in the earlier experiments with tail withdrawal This arrangement made possible the use of the original recording and stimulating apparatus with a minimum of readjustment and served to keep the spatial relationships between buzzer, recording apparatus, experimenter, and rat essentially the same as they were in the earlier studies.

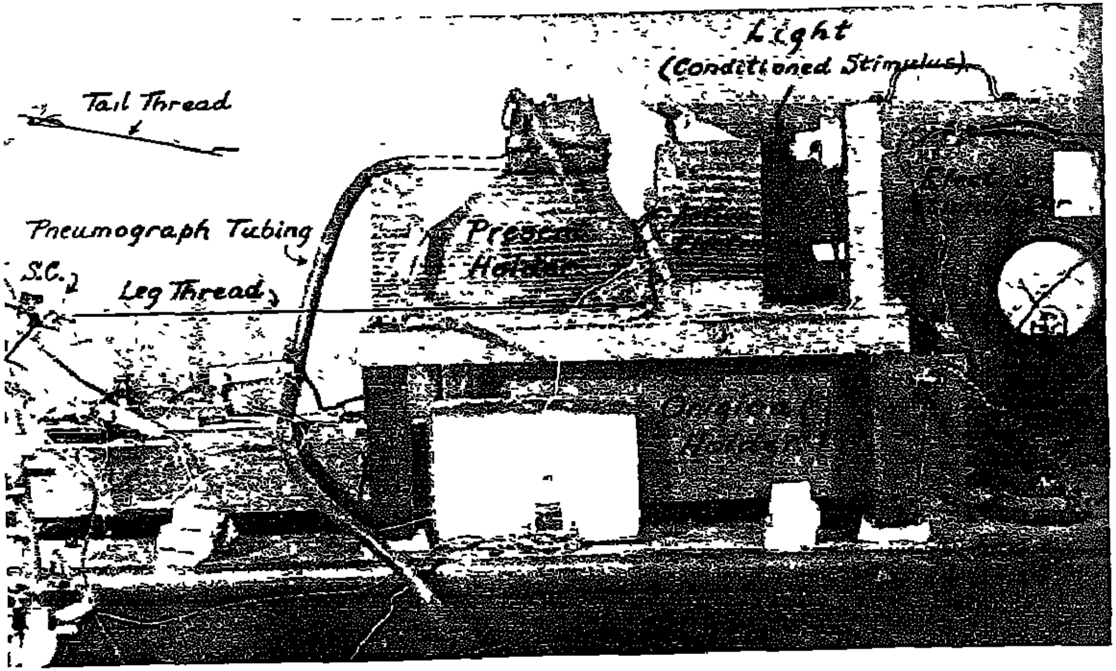

FIGURE 1
The Holder and Associated Apparatus
[For description, see text, and (19)]

In some of the later experiments, it seemed desirable to have a record of the reactions of the tail even though this member was not stimulated in the present study. A lever was added, pivoted so that it would record directly on the kymograph. It reduced the reactions on the record to one-third of their actual extent. A thread passed from this lever to a hook, fastened with adhesive tape near the end of the tail. The records obtained with this arrangement were badly distorted by inertia, but we were not as much interested in the actual shape of the curves as in whether or not the tail moved. A stop limited the excursion of the lever to two centimeters, to keep the stylus on the record.

GENERAL METHOD

The method used in the present experiment does not differ materially from that reported earlier, but it may be summarized here. The training was divided into daily sessions of 30 minutes each, during which 25 stimulations, paired or single, were given. Buzz (*B*) or light (*L*), the conditioned stimuli, were presented for 50 seconds. Foreleg shock (*S*), the unconditioned stimulus, lasted for 17 seconds. The *S* of a double stimulation (*BS* or *LS*) ended simultaneously with the conditioned stimulus. Two rats were always trained concurrently, partly because of the saving in time involved in preparing the apparatus, but largely because it made possible the determination of the effects of slight modifications in the training conditions. Thus two rats were brought from their living cages in the basement to the experimental room on the third floor. One animal was left in another room, while the first animal was placed in the holder. Twenty-five stimulations were then presented at predetermined, but irregular, intervals during the next 25 minutes. The rats were then interchanged, and the second rat was subjected to exactly the same stimulation already used on his "experimental mate." The only difference between the two sessions was the inclusion of the short-circuiting contacts (*SC*) in the shocking circuit of one rat, permitting him to terminate the shock by the first millimeter of leg withdrawal. The other animal (*noSC*) always received a shock of 17 seconds' duration, regardless of his response.

Before training, two or more sessions were devoted to pretraining, to eliminate the struggling that appeared the first time the animal was restrained in the holder. These sessions were carried out in the same general manner as any other sessions, except that no stimuli were presented From two to four pretraining sessions were usually sufficient. After the animal became reconciled to the holder, "pretests" were made to determine the original effects of the to-be-conditioned stimulus *B* (or *L*), an "indifferent" stimulus *L* (or *B*), and the unconditioned stimulus *S*. The duration of the pretesting varied somewhat from experiment to experiment and will be indicated in each case After the pretesting, the regular conditioning sessions were started. Of the 25 stimulations presented during each of the conditioning sessions, 15 to 23 (varying from experiment to experiment—see Figures 3-5) were paired presentations of the conditioned and unconditioned stimuli. The remaining stimulations were divided between isolated test presentations of conditioned stimuli and of unconditioned and indifferent stimuli. It should be noted that the indifferent stimulus was never reinforced.

Ten albino rats were used during the experiments to be reported. They were males, of Wistar Institute, common stock, in good health, and between 6 and 12 months in age They had not been used in other experiments but were relatively tame as a result of handling during the routine of daily care. Each pair of animals that was trained will be described as a separate experiment. Since the purpose of the investigation was exploratory, the conditions were varied for each experiment This technique will uncover only the grossest of differences, but it seems preferable at the present stage of investigation to cover as much ground as possible, rather than to look for minor differences in large numbers of animals. The experiments and their results will be presented in the following charts and text, in some detail, and the discussion will be largely reserved for the later sections of the paper It is hoped that this method will show a number of facts that might be lost in statistical treatment of the results, while avoiding the errors of interpretation that might occur if we first presented our generalizations and then illustrated them with experiments (cf. Pavlov). It should be particularly noted that the rats were not selected on the basis of any behavioral differences, and that no rat was discarded after he had been assigned to the problem. The results, therefore, may be said to indicate what may be expected from animals selected at random from a typical strain of white rats.

EXPERIMENT I

(See *General Method* for abbreviations)

Rats A0 and A1 were each given 20 conditioning sessions with a total of 500 stimulations consisting of 311 *BS*, 104 *B*, 20 *S*, and 65 *L*. The number of reinforcements (*BS*) during each session may be computed from the cumulative totals in Figure 3. Before the 20 training sessions, there had been several "pretraining" sessions and one "pretest" period After the final training session, one period was devoted to "experimental extinction" Rat A0 was *noSC*, rat A1 was *SC*.

1. *The Development of Conditioning in Rat A0* Before the first stimulation of the "pretest" session, the rat was breathing regularly, yielding the sinusoidal curve that is typical of rapid breathing in the rat (19) Upon stimulation by *B*, the rat increased the rate of breathing slightly and shifted the level toward the inspiratory position During two presentations of *L*, and three more of *B* there was little indication that the rat had been stimulated (Figure 2, *A*). Stimulation 7 (*S*, .1 ma in intensity) elicited a sharp inspiration and foreleg withdrawal As the rat breathed out, it squealed loudly Similar results followed the next four presentations of *S* At first the behavior immediately after *S* was erratic, but by the fifth *S* the rat was returning to relatively normal breathing and leg position within a few seconds after each stimulation (See Figure 2, *B*.) However, the rat was somewhat excited throughout this whole session, and frequently showed short bursts of struggling and squealing between stimulations. Sometimes the struggles were clearly the immediate results of external stimulation, while at other times they were "spontaneous." Parenthetically, it should be noted that stimuli were never intentionally presented during struggling, but occasional chance coincidence of stimulation and struggling must be discounted in our results Such chance coincidence is rare, especially after some training, and can readily be detected because of the precise temporal relationships between stimuli and responses Furthermore, as we will see later, the well-developed conditioned response does not closely resemble a struggle and can be differentiated from it rather easily.

After five additional *S*, 3 *B* and 1 *L* failed to elicit responses The session was concluded after two more presentations of *S*. We

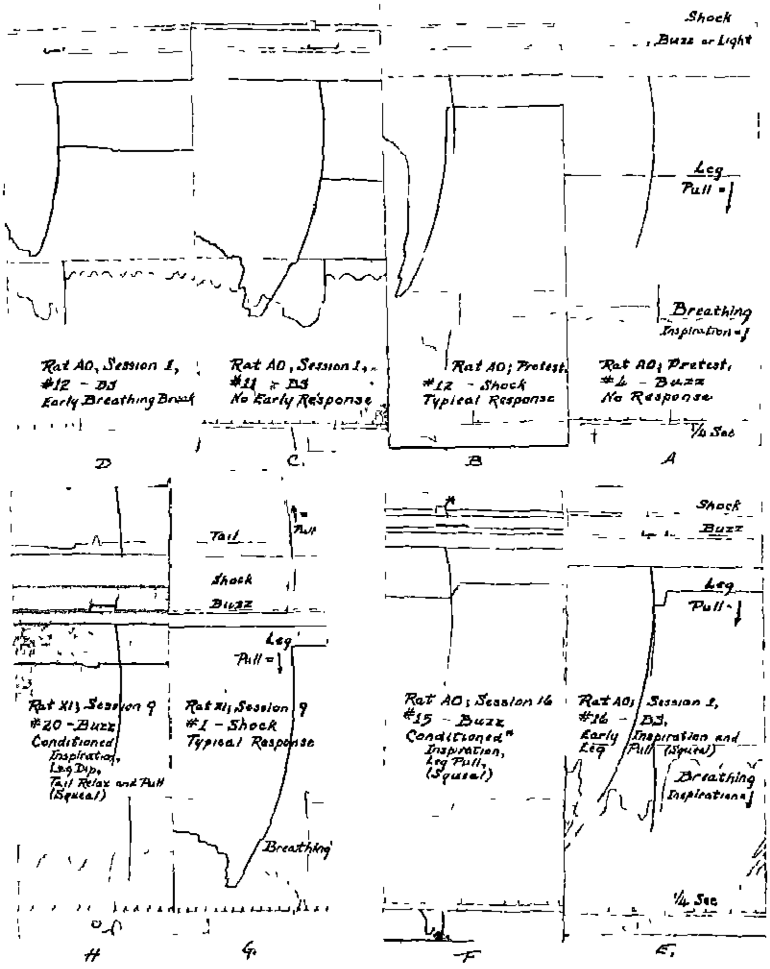

FIGURE 2

These records should be read from right to left They are negative prints of the original kymograph records The simultaneous ordinates were added before the records were removed from the kymograph and are accurate to 1 seconds Ordinates in *A* and *H* indicate the onset of buzz, while others mark the beginning of the shock Certain of the time and signal lines have been "touched up" in the prints, for their excursion was limited by padding

*Note that in *F*, although a shock is indicated, the early leg withdrawal had short-circuited the electrodes It is, therefore, equivalent to a test presentation of buzz may summarize this "pretest" period by pointing out that, before training, *S* regularly elicited an inspiration, squeal, and leg withdrawal, while *B* or *L* rarely evoked a response except when the animal was already about to struggle.

At the beginning of the first training session *B* and *L* each elicited *a sharp inspiration and squeal, but no leg response.* These cannot *be called conditioned responses to B or to L,* since neither of these stimuli had been paired with *S* as yet. This matter will be discussed later. At any rate, the response dropped out during three additional presentations of *B* and *L*. We were then ready to begin actual conditioning.

The first four *BS* stimulations resulted in responses that were indistinguishable from those made to *S* alone (as in Figure 2, *C*), but the next *BS* yielded the first indication of conditioning (Figure 2, *D*). *B* was presented near the end of an expiration. The next inspiration was slightly deeper than the preceding ones, and the ensuing expiration was checked by the response to *S*. In the charts, such reactions will be entered as unfilled columns indicating "breathing changes other than sharp inspirations." They may be considered a form of conditioning, but not a particularly reliable one.

After these five reinforcements, isolated presentations of *B* and *L* were both negative as was the sixth *BS*. But about 1 seconds after *the onset of B of the next BS, the rat gave a sharp inspiration and* withdrew the leg two millimeters (Figure 2, *E*) before the shock was presented. The inspiration was not as sharp as that elicited by *S*, and the leg reaction was only one-twentieth as strong as the full withdrawal, but they both had something of the abrupt nature of the unconditioned response and are therefore considered as typical conditioned responses. Such reactions will be called "inspirations" and "leg pulls" respectively, and will be entered in all charts as solid blocking to set them off from the hollow blocking used to indicate the less significant "other responses." Similar early inspirations, but not early leg pulls, were recorded on the next two reinforcements, and the tenth *BS* was negative. After this, a "test" presentation of *B* resulted in a very sharp inspiration, leg pull, and squeal, almost indistinguishable from the usual reaction to *S*. A strong conditioned reaction of this type is decidedly not typical at this stage of conditioning. The next *B* resulted in a more hesitat*ing response, and a third B elicited* a small inspiration, two-millimeter leg pull, and squeal, with a latency of .75 seconds. Even this reaction is exceptional, as we shall see when we examine the other animals to be reported

One *L* was then ineffective and no early responses were recorded upon presentation of the last two stimulations (*BS*) of the series The results of the session are summarized in the chart (Figure 3)

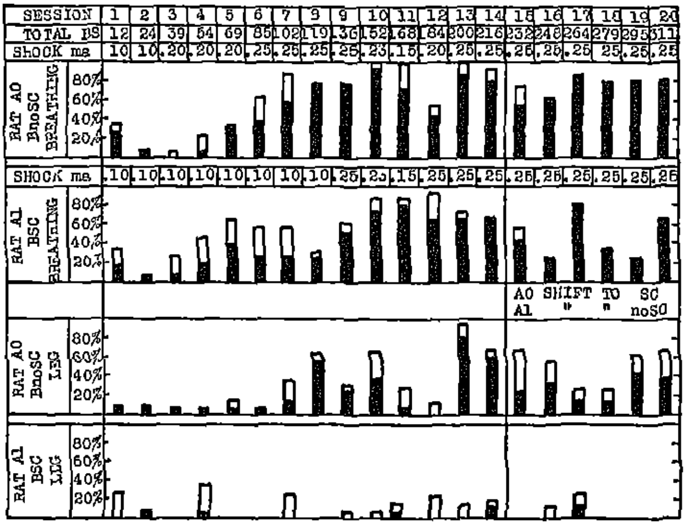

FIGURE 3

PERCENTAGE INCIDENCE OF EARLY BREATHING AND LEG RESPONSES, EXPERIMENT I

Key —"*Total BS*" indicates the total number of reinforcements to the end of each session, "*Shock*" values are given in milliamperes *Solid Columns* indicate the percentage incidence of sharp early inspirations or leg withdrawals, while *Hollow Columns* show other responses *BSC* indicates the use of the short-circuiting contacts, *BnoSC,* their omission (Note reversed conditions after Session 14)

which represents the early responses observed during double stimulation.[2] It will be seen that 12 *BS* stimulations were enough to establish some indications of conditioning

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[2] *The results of the "test" presentations of B have been tabulated for* these animals but will not be reproduced in this paper Because of the relatively few "tests" during each session, the values obtained from this index were not stable, but they were found to parallel, in a rough way, the values obtained from early responses (See Experiment IV.)

An examination of the results of the next two sessions, as presented in the same chart, will show that conditioning was by no means stable. During the third session there were almost no indications of conditioning This loss may be attributed to a weakening of the unconditioned reaction itself, for, during the third session, the rat barely moved his leg in response to *S* Increasing the shock to 2 ma. led to a slight improvement during sessions 4 and 5. Subsequent increases and decreases of the strength of the shock led to corresponding changes in the incidence of early breathing and leg reactions until, during sessions 13 and 14, the rat showed an average incidence of 83 per cent for early inspirations and of 70 per cent for leg pulls Buzzes presented as simulations 13, 20, 21, and 22 consistently elicited inspirations, leg pulls, and squeals. *L*, the "indifferent" stimulus, was ineffective. About the only *B* stimulations that did not elicit conditioned responses were the first few of each session. This probably does not indicate a great deal of "forgetting" over-night, but seems more comparable to the "warming-up" part of a work curve In an earlier paper (19) we have discussed this point and indicated that several stimulations by *BS*, *S*, or *B* will serve to bring the animal up to an effective level of performance [Cf. Liddell's (12) use of a "priming" shock.]

If we discount the "warming-up period" at the beginning of each session, we may say that rat A0 had developed a fairly stable conditioned inspiration, leg pull, and squeal after 13 or 14 experimental sessions, a total of 200 paired presentations of *B* and *S*. We will now leave this animal for a time and consider the results obtained from his experimental mate

2. *The Development of Conditioning in Rat A1.* During the "pretest" period, Rat A1 was more active than A0 *B* elicited a shift from slow to rapid breathing, a shift in level, or slight inspirations about half the time (four out of seven). At the beginning of the first training session, *B* and *L* again called out breathing responses. Training was then started with a shock of .1 ma. (*SC*). Out of 12 *BS* stimulations, two resulted in early inspirations, and two in other early breathing responses There were also three leg reactions that we have classified as "*other leg reactions*" In this case they consisted of one slight relaxation or extension of the leg and two slight tremors. Three presentations of *B* near the end of the session resulted in inspirations with a latency of one second followed by squeals but no leg responses.

We need not devote more space to a detailed description of the development of conditioning in this rat An inspection of Figure 3 will show that he developed a conditioned breathing response somewhat more rapidly than did Rat A0 during the early sessions but that he fell behind during sessions 6-9. This may be partially attributed to a weaker shock, made necessary by his greater excitability, for the incidence of early breathing responses for A1 approaches that for A0 during sessions 10-14, when the shocks were of equal strength. But A1 never developed a stable leg response during these 14 sessions, totalling more than 200 reinforcements

3. *The Effects of the Short-Circuiting Contacts.* In previous papers (19) we have shown that the use of contacts so arranged that they prevent or terminate the shock as soon as the rat responds (tail withdrawal) do not materially modify the progress of conditioning. And now in the present experiment we see that A0, the *noSC* animal, actually conditioned more completely than did A1, the *SC* rat This was true in spite of the fact that A0 had never terminated or avoided the shock by his response to it, while A1 had regularly terminated the shock by each withdrawal. It should be noted, however, that A1 had completely avoided the shock by an early response only four times during 200 stimulations. It seemed desirable to see what would happen when a rat consistently prevented the shock by his response to the buzz Therefore, the two training situations were reversed, rat A0 to *SC,* and A1 to *noSC,* starting with session 15

Rat A1 became quite excitable under the new conditions, presumably because of the increased duration of the shock, since the rat could no longer terminate the shock before the full .17 seconds had elapsed. Many of the responses during the next six sessions could not be scored with any degree of assurance because of the confusing effect of the intermittent struggles The values plotted for sessions 15-20 for this rat (Figure 3) should therefore be accepted with caution, but they do indicate that conditioning fell oft somewhat under the new conditions.

Rat A0 showed much more interesting behavior It will be recalled that he had developed a stable withdrawal response under *noSC* conditions Under the *SC* conditions, he avoided the first shock by early leg withdrawal (Figure 2, *F*). The omission of the shock led to weakening of the response so that on the next three

BS stimulations no early leg response was obtained. But these three reinforcements again strengthened the response so that he avoided the shock by early withdrawals on the next three *BS* stimulations. This alternate waxing and waning of the response continued during the remaining five sessions, with no single sequence showing more than six successive early leg responses Superimposed on these short cycles was a gradual falling off of conditioning during sessions 15-18, with a slight recovery during the last two sessions The results with this animal may be summarized most readily by saying that a withdrawal that prevents the shock leads to "experimental extinction" of the conditioned response, instead of to a "stamping in" of the "successful" response.

4. *Experimental Extinction* Session 20 was devoted to the study of "experimental extinction." Stimulations were spaced by 30-90 seconds, according to the usual stimulation schedule The results will not be presented in detail but may be summarized as follows

Rat A0 Six buzzes resulted in six sharp inspirations, one of which was accompanied by leg pull and squeal. *L* was ineffective three times in succession After one reinforcement (the first *BS* of the session), the response to *B* gradually increased until it consisted of inspiration, leg pull, and squeal about half the time The latency of the responses was long, varying up to one second. The response then fell off, so that at the end of the session the eleventh *B* since reinforcement was ineffective, and the twelfth elicited only an inspiration and squeal but not a leg response

Rat A1. This animal responded to every one of 20 buzzes with an inspiration and squeal of 1 to .3 second's latency. During the last part of the session, nine out of 12 buzzes also elicited slight leg movements under one millimeter in extent There was, in other words, no indication of extinction after 20 unreinforced presentations of the conditioned stimulus Five presentations of the "indifferent" *L*, a stimulus that had never been reinforced, elicited about the same responses as *B* but weaker and less consistently This pronounced "generalization" is another indication that rat A1 never developed a very stable conditioned response

EXPERIMENT II

This experiment differed from the preceding one chiefly in the use of *L* instead of *B* as the conditioned stimulus Six training sessions (total of 90 *LS*) were given to each of two rats, A2 (*SC*) and

A3 (*noSC*), in addition to pretraining, pretesting, and an extinction session.

1. *The Effectiveness of the Stimuli before Training.* At the start of the "pretest" session, *B* and *L* were each presented four times to each rat. A2 made no response to *B*, but showed a slight break in breathing rhythm to one *L* and a delayed (1.0 second) inspiration and leg movement (.5 millimeter) to another *L*. Rat A3 was somewhat more active, responding with a slight shift in the speed or level of breathing to each *B* and to 3 *L*. The remaining *L* elicited a struggle, after a latency of two seconds. After the determination of shock thresholds (see below) *B* and *L* were again tested and found to elicit no observable responses in either animal.

The rest of the session was devoted to an ascending and descending series of shocks in an attempt to determine the thresholds for both animals. During the ascending series both rats showed the first clear-cut response to a shock of .08 ma. The response involved a slight break in the breathing curve, and a leg withdrawal of one millimeter. A shock of .15 ma. resulted in an inspiration, squeal, and leg pull (two to three centimeters, as measured on the record). A shock of .25 ma. elicited similar responses, with the leg pull reaching an amplitude of 4.5 centimeters for rat A2, and four centimeters for A3. These responses had all been recorded with the *SC* contacts in the circuit so the actual duration of the stronger shocks was about .1 seconds rather than .17 seconds. Omission of the *SC* contacts increased the response by .5 centimeters. During a descending series, the leg response dropped out below .1 ma., but a slight inspiration and squeal was still observed at .05 ma. Thus the threshold for both of these animals (with the apparatus described) was between .05 and .1 ma. It was decided to use a shock of .2 ma. during the early training of each animal. The inclusion of the *SC* contacts in the circuit of rat A2, the more active animal, thus decreasing the duration of the shock, made the responses of both rats approximately equal in amplitude.

2. *The Development of Conditioning.* An examination of Figure 4 will show that both of these rats developed conditioned breathing responses quite rapidly. During the second training session, A2 responded to every *LS* by an early sharp inspiration and only failed six out of 60 times during the remaining four sessions. He responded with an inspiration and squeal to practically every test

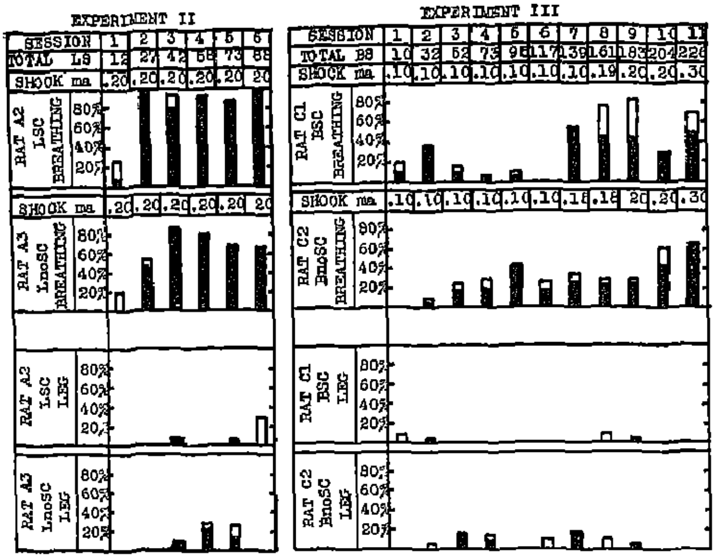

FIGURE 4
FOR EXPLANATION, SEE FIGURE 3 AND TEXT

presentation of *L*, with the exception of the "warming-up" stimulations given at the beginning of each session (see above). The first conditioned inspiration and squeal occurred after only five reinforcements.

In spite of this rapid development of conditioned breathing reactions, the rat never developed a very stable leg withdrawal. During the whole six sessions only two early leg pulls and four slight early leg movements (one millimeter) were recorded This poor showing may be partially attributed to the latency of the conditioned leg reaction. During the last four sessions, five full leg pulls were obtained out of 14 legible records of the response to test presentations of *L*. The latency of these responses varied around 4 seconds so that any leg response that would have been elicited by *L* of a paired stimulation would usually have been masked by the response to the *S* component But even on the test presentations of *L* this animal showed a relatively low incidence of leg responses. In addition, the conditioned response was so "generalized" that it appeared fully as often to the "indifferent" stimulus, *B*, as to the conditioned stimulus, *L*.

Rat A3 conditioned somewhat more slowly Figure 2 shows that the early inspirations reached their maximum on the third day and then fell off during the remaining sessions, never reaching the high value shown by A2. The early leg reactions reached their greatest frequency during session 4 when they occurred 30 per cent of the time—a trifle better than A2. On test presentations of *L* the response was more prompt than that of A2 so the incidence of all responses on tests closely paralleled that obtained from early responses

The training was discontinued after session 6, for the curves were all falling and there was no indication that conditioning would improve with additional training It will be noted that these two rats reached their maximum level of conditioning much sooner than did those of Experiment I, probably because they had been started with a stronger shock The other possible explanation, that *L* is a more effective conditioned stimulus than *B*, is unlikely, as we will try to show later.

3 *Experimental Extinction* In response to the first *L* of the extinction session, rat A2 responded with two unvocalized squeals That is, although no squeal could be heard, the breathing pattern showed the characteristic curve that occurs when a rat squeals—a sharp inspiration, a plateau-like period during which the breath is slowly expelled, and a sharp expiration (as on record *B*, Figure 2) The actual amplitude of the response was no greater than that of the usual breathing A similar response was elicited by *L* for seven times in succession. On two occasions reinforcement (*LS*) increased the response so that it was vocalized, but in each case it returned to the previous level after one or two unreinforced presentations of *L*. No conditioned leg withdrawals were observed during this session with rat A2.

Rat A3 was much more active. The response to the first *L* was obscured by an irregular breathing line, but the second *L* elicited an inspiration and a loud squeal. On the next *L*, an irregular step-like leg withdrawal was added The response then waned but recovered without additional reinforcement Toward the end of the session, after 15 unreinforced presentations of *L*, three conditioned inspirations, squeals, and leg responses were recorded Two of the leg responses were full withdrawals, of long latency (one and two seconds, respectively) and the other was a two-millimeter leg movement of normal latency (.3 seconds)

EXPERIMENT III

This experiment was planned to test the effectiveness of sessions in which the conditioned stimulus was always reinforced, to avoid the possibility of setting up inhibitions by test presentations. Rats C1 and C2 were each given 11 training sessions, each session (except the first—see below) consisting of 22 *BS* stimulations, and three presentations of *L*, to check generalization. They were pretrained, but no separate "pretest" session was used. Instead, the first half of the first training session was used for "pretesting" In this period it was found that *B* and *L* were both ineffective in eliciting original responses from both animals. The threshold for *S* was lower than it had been for rats A2 and A3, being about .02 ma. A shock of 1 ma resulted in an average leg withdrawal of 4 5 centimeters with rat C1, and of three centimeters with C2. Conditioning was started with a shock of this strength, with C1 as the *SC* animal.

An examination of Figure 4 will show that conditioning developed slowly, early inspirations rarely exceeding an incidence of 50 per cent during 11 sessions, totalling 226 reinforcements The leg reactions were correspondingly infrequent. The experiment was discontinued after 11 sessions with no attempt made at extinction

The low level of conditioning obtained in this experiment may have been partly due to the strength of the shock. During the early sessions .1 ma. was used, and later, .2 ma. and .3 ma. As an absolute value this is low, compared to that usually employed, but it was sufficient to elicit a strong reaction, which is probably as significant as the absolute strength We hesitate to conclude that the poor conditioning was largely due to the omission of "tests," but we feel safe in making the more conservative conclusion that occasional tests do not retard the development of conditioning.

EXPERIMENT IV

Frequently during the first three experiments we had noticed that the shock elicited a lifting and curling of the tail, and that this reaction sometimes became conditioned Therefore, the tail lever already described (under *Apparatus*) was added and used during this experiment. It should be noted that the tail was *never* shocked so that the response must be considered a component of the reaction to the leg shock. The tail reaction reported here must not be confused with that described in the first paper of this series, in which the shock had been applied to the tail.

Certain other modifications were made in the procedure used in Experiment III. The shock was kept at a higher value throughout. Beginning with session 6, four to seven test presentations of *B* were made during each session to furnish a second index of conditioning. Finally, beginning with session 8, the first two stimulations of each session were isolated shocks, to eliminate the "warming-up" period. Two rats, X1 and X2, were carried through 15 sessions (258 *BS*) in addition to pretraining and pretest sessions.

1. *Original Effects of the Stimuli.* The first six stimulations of the pretest session were devoted to a short ascending and descending series of shocks. A shock of 05 ma. elicited a slight inspiration and squeal, but no leg reaction, in rat X1, while in X2 it elicited a similar reaction, except that the squeal was whispered, rather than vocalized. A shock of 2 ma elicited a consistent inspiration, squeal, and leg withdrawal in rat *X2* and a more variable reaction in *X1*. It was decided to start training with a shock of 2 ma, using the *SC* contacts with *X2*.

After the determination of thresholds, the animals were tested for their responses to *B*. Rat X1 made no responses, and X2 made no clear-cut ones, but we can be less certain of this latter point since rat X2 showed a somewhat irregular breathing line at the time.

2. *The Development of Conditioning (Except Tail Reactions).* An examination of the bars representing the percentage incidence of early breathing reactions in Figure 5 will show that the development of this response was rather slow, but fairly steady. In fact, if some allowance is made for variation, the results approximate a typical learning curve, levelling off during sessions 5 or 6 with an incidence of slightly better than 80 per cent. The incidence does not go beyond this value for any protracted period, in spite of increased shock. The incidence of early leg reactions is much lower and more irregular than that of breathing changes. In addition to the data from early responses, there are also available the records of the responses to test presentations of *B*. Since such tests were used

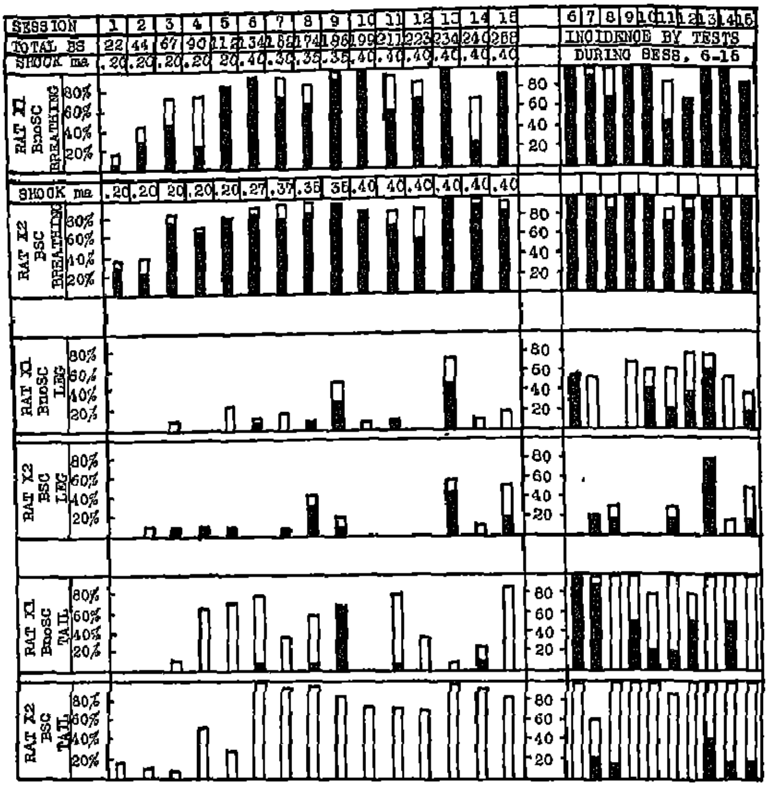

FIGURE 5

EXPERIMENT IV. FOR EXPLANATION, SEE FIGURE 3 AND TEXT

The incidence of *Early* responses is shown on the left

The incidence of responses during *Tests*, sessions 6-15, is shown on the right.

more freely, starting with session 6, than they had been in Experiments I-III, it becomes worthwhile to include them in the published chart. Therefore, on the right side of Figure 5 will be found the percentage incidence of breathing, leg, and tail responses observed on test presentations of *B*, sessions 6-15. An examination of the breathing responses will show that both criteria of conditioning yield closely parallel results, with the data from "tests" showing slightly higher values. The disparity between the two indices is somewhat greater for leg reactions, largely because conditioned responses of long latency, that would not have shown as earlies, do show up on the tests (See Experiments I and II.) In making these comparisons, it must be remembered that one failure to respond to a "test" will change the incidence by 15-25 per cent. Therefore, the close correspondence between the two indices is rather surprising.

The frequencies with which the tests elicited squeals have been tabulated, but cannot readily be included in the chart, for they have no parallel in early responses. The incidence of squeals, session for session, is almost identical with that for sharp inspirations Indeed, this would necessarily be true, for the typical sharp inspiration ends in a squeal

Considering all of our data from this experiment, we see that a fairly consistent conditioned inspiration and squeal was set up in both rats during five sessions, after 100 reinforcements, but that the leg withdrawals did not become stabilized during 15 sessions The conditioning developed a trifle more slowly than it did in Experiment II in which a shock of similar strength had been used, but more rapidly than in the two experiments (I and III) in which a weaker shock had been employed. On the other hand, the conditioned leg reaction never became as stable as it had in the exceptional rat A0. Comparing the rats of this experiment with each other, we find that there is no obvious difference between the results obtained from X2, the animal that could terminate the shock by withdrawal, and X1, the rat that always received a shock of fixed duration In passing, it may be noted that X2 *avoided* the shock by an early leg withdrawal only nine times during 258 presentations of *BS*.

Before turning to a description of the tail responses it seems advisable to comment on the other variations that were made in this experiment First, the inclusion of four to seven test presentations of *B* has furnished us with an index of conditioning that is superior in some ways to that obtained from early responses The tests do not seem to have retarded conditioning, for there is no drop in the indices of conditioning after these tests were started in session 6 Secondly, the use of two "energizing" shocks at the beginning of the session, starting on the eighth day, apparently did not materially modify the rate of conditioning. The chief advantage of these shocks is that they put the animal in an alert state at the beginning of the session, thus making the first few responses comparable to the later ones As a matter of fact, it was the use of "energizing" shocks that made practical the use of test presentations of the conditioned stimulus as a stable index of conditioning. In Experiments I and II presentations of *B* or *L* at the beginning of a session fell in the "warming-up" period and were usually negative But in the present experiment, tests made at the beginning of a session, immediately after the two shocks, were quite as apt to be positive, as were the later ones, and could therefore be included in the index

3. *Tail Reactions* The tail reaction to a shock on the foreleg consisted of a stiffening of the tail, usually followed by a flailing or arcing The flailing might be continuous with the stiffening or might follow it by as much as .3 seconds The stiffening showed as a fall in the record as the weight of the tail was removed from the recording system (*Notice the sag in the tail, Figure 1*) The flailing appeared as a sharp upward excursion of the recording lever. (Figure 2, *G,* shows both responses.) Approximately half of the reactions to shock did not show the preliminary stiffening, presumably because the flailing started before the relatively slow recording system had taken up the slack resulting from the stiffening The latency of the unconditioned tail reactions was about the same as that of the unconditioned breathing and tail responses, that is, below 1 seconds

Both of these tail reactions became conditioned to *B.* (See Figure 2, *H.*) An examination of Figure 5 (open boxes) will show that conditioned tail stiffening occurred almost as frequently as did sharp inspirations The flailing responses (*filled* boxes) occurred somewhat less frequently, as measured by early reactions, than did leg pulls But a somewhat better indication of the extent to which these responses were conditioned is furnished by their incidence on test presentations of *B,* since the latency of these conditioned responses was often longer than the .33 seconds which elapsed between *B* and *S* of a double stimulation (The record in Figure 2, *H* of X1, session 9, stimulus 20, shows conditioned tail and leg reactions with a latency of approximately one-third second.) Thus X2 showed no early flailing responses but did respond in this fashion to 10 per cent of the isolated presentations of *B* Comparing the incidence of the flailing reaction with that of leg pulls, both determined on test presentations of *B,* we find that X2 developed more frequent leg withdrawals, and that X1 showed a higher incidence of tail flailings. The significance of these results will be discussed later

EXPERIMENT V

In Experiments I-IV we had used the shocking apparatus described in the first paper of this series (19). It furnished a half-wave rectified 60-cycle A. C. at 50-500 volts, through 550,000 ohms resistance external to the rat. This should have furnished a shock consisting of 60 equal pulses per second, lasting for .17 seconds unless terminated sooner by the *SC* contacts The behavior of the rats bore out the theoretical prediction as did the reports of human subjects who tested the shock It was feared, however, that this evidence did not completely eliminate the possibility that polarization was cutting down the effectiveness of the shock toward the end of its duration The question seemed particularly important when we considered the effects of the *SC* contacts If most of the shock occurred at the onset of the current, the rat would not materially decrease its effectiveness by cutting off the last half of it In that case, there would be little difference between the *SC* and *noSC* situations Threshold tests (see Experiment II) indicated that this fear was probably groundless, but in the interests of caution it seemed desirable to train a pair of animals with a more traditional type of shock A Harvard inductorium was therefore substituted for the more complicated shocking apparatus. The primary coil was actuated directly from a transformer (2-volt, 60-cycle) with the uncertain "automatic" interrupter omitted. The induced 60-cycle A. C should have been free from polarizing effects. To obtain a current of satisfactory strength, the 550,000-ohm external resistor was omitted. Two rats, X3 (*SC*) and X4 (*noSC*), were trained through five sessions, using the secondary coil at 3 5-5 centimeters from the primary.

The results obtained from these animals were very similar to those from the first five sessions of Experiment IV It scarcely seems necessary to present them in detail, using a separate chart. The average incidence of early inspirations during sessions 2-5 was 42 per cent for X3, and 62 per cent for X4. Similar figures for early leg pulls were 3 per cent and 5 per cent, respectively, and for all tail reactions, 6 per cent and 31 per cent The only index in which these rats differed materially from those of Experiment IV was that for tail stiffening, an index which is distinctly a function of the tension on the tail. The close similarity between the results obtained from these two experiments indicates that the two different types of shock were equally effective as unconditioned stimuli. Further, X3, the *SC* animal, certainly did not show better conditioning than X4, the *noSC* rat. This result shows clearly that no peculiar characteristic of the shock used in Experiments I-IV and in the earlier studies was responsible for our failure to obtain more complete conditioning in those animals that could prevent or terminate the shock by their response.

Discussion of the General Results

During our description of the five separate experiments, it occasionally seemed necessary to indicate certain general relationships between the results obtained under different conditions. But in general we have kept such discussion at a minimum, reserving fuller consideration of our results until they were all available at one time In the following pages we will try to indicate the more important generalizations that seem justified by our results.

1. *The Responses Developed.* Every one of the experiments indicated that modification of the breathing curve is rather easily brought about by repeated presentation of buzz or light, paired with a shock to the foreleg. After a few such reinforcements *B* or *L* will usually elicit a slight change in the breathing rhythm (Figure 2, *D*). The next response to develop consists of a sharp inspiration, typically followed by slow plateau-like expiration, during which the animal squeals (Figure 2, *F*, *H*, and early on *E*). This response may appear during the first training session and, under favorable conditions, reaches a maximum incidence of better than 80 per cent after one to five sessions, or 12-75 reinforcements. The components of this pattern vary somewhat in strength and form from time to time and from rat to rat The latency of the inspiration itself is usually about .1 seconds, after it is well established, so that the inspiration may be observed as an early response occurring before *S* of a *BS* stimulation If the conditioning is less well advanced, the latency may be considerably longer so that some of these breathing responses are masked by the response to shock. The other element of the pattern (squeals) can rarely be observed as early responses and must be studied by isolated "test" presentations of the conditioned stimulus.

The establishment of a conditioned leg response is much more difficult and uncertain. A well-developed conditioned withdrawal shows a sharp jerk with a latency of .1-.3 seconds that brings the foot to a fully flexed position, followed by a gradual relaxation to the extended position The early phases of such a stable response can be observed before the *S* of a *BS* stimulation, but if conditioning is less stable, the latency of the response may be as much as one second so that the withdrawal can only be observed on "tests" One rat, (A0), developed an incidence of 80 per cent for this response during session 8 and maintained it above 70 per cent (with one lapse) through session 14 No other rat even approached this level The next best animal, X1, had an average incidence of 15 per cent during sessions 10-13, as measured by early responses. When the incidence for X1 was determined by the more sensitive index derived from "tests," it became 57 per cent, indicating that most of the responses had a long latency. The remaining animals showed only occasional conditioned leg withdrawals.

In addition to the sharp leg pulls, there were a number of smaller responses that have been lumped under the general heading of "leg responses other than sharp withdrawals." Their combined incidence, on the average, was about the same as that of the sharp pulls. Their latency was also the same. They consisted mainly of slight movements of the leg, such as active or passive extensions or lateral movements that obviously could not be considered as withdrawals. They showed on the records as slight rises or dips or both combined in a ripple. All movements that showed as rises in the record or that caused falls of less than five millimeters were arbitrarily classified as "other leg movements" (Note that a pull causes a downward movement on the record) It is undoubtedly true that this or any other arbitrary criterion will result in the inclusion of slight withdrawals in the category of "other leg responses." However, most examples of the two types of response were different enough to permit their separation into two groups, and a change of a few millimeters in the line of demarcation would have changed only a few responses from one class to the other (In Figure 2, *E* shows an early withdrawal, *F* shows one not masked by *S*, and *H* shows a drop.)

Finally, it was found that tail reactions occur as part of the response to a shock on the foreleg and that these responses may be conditioned. (Rats X1-X4.) These responses may also be divided into two classes, a preliminary stiffening, showing on the records as a slight (1-2 millimeter) downward excursion, and a flailing movement, recorded as a sharp upward excursion (1-3 centimeters). Both are shown on Figure 2, *H* The conditioned flailing movements show about the same incidence (when determined from "tests") as do the conditioned leg withdrawals, but because of their long latency they are not adequately observed as early responses The stiffening reaction may show a higher incidence, but the value obtained is probably partly a function of the tension and inertia of the recording system

2 *The Relationship between Conditioned and Unconditioned Reactions.* There has been a great deal of discussion, particularly during the last few years, as to whether or not the conditioned response is the same as the unconditioned one Much of this discussion has been summarized by Hull (8, p. 429). As the present writer reported in 1928 for the human conditioned knee jerk (15) and in 1934 for the conditioned tail withdrawal in the rat (19), there seem to be certain differences between the conditioned and unconditioned responses Similarly in the present paper we have indicated that the conditioned responses developed are slower and weaker than the unconditioned ones on which they are based. Such differences in the latency, form, and amplitude are to be expected since different receptors, and presumably different neural arcs, are involved in the conditioned and unconditioned responses But if we adopt a less atomistic view, the similarities between the two responses stand out We have already indicated that the behavior elicited in a rat by electric shock varies with the strength of the shock and the condition of the animal A calm animal will respond to a shock of threshold value with a slight change in amplitude, form, frequency, or level of the breathing curve [cf "Flutter Response" (23) and "Lullaby Effect" (22)] As the shock is increased in strength, or as the rat becomes more excited, the behavior becomes more elaborate, involving sharp inspirations, widely distributed tonic changes (as tail reactions and leg relaxations), squeals, and withdrawal of the stimulated member, culminating in flight, or, if the animal is restrained, in struggling. Instead of treating each of these elements as a separate response, it is possible to consider the whole mass of behavior as a single integrated pattern, ranging from some-

thing like the famous "investigatory reflex" to complete withdrawal, depending on the strength of the stimulus and the condition of the animal If we use the term "unconditioned response" for this more-or-less integrated pattern of behavior, we can say that the conditioned response is quite similar to the unconditioned one in every respect except strength The breathing changes of the "flutter" type will not be considered to be new responses but rather an early stage of the conditioned response closely resembling the unconditioned response to a weak shock And as conditioning continues, and the conditioned response increases in strength, it resembles the response elicited by a stronger and stronger shock Under the present experimental set-up, it is usually not possible to establish a conditioned response as extensive as that which may be elicited by a brisk shock This is shown particularly by our inability to develop a stable conditioned foreleg withdrawal in eight out of ten rats. Other indications of the relative weakness of the conditioned response were the instability of its elements, the marked generalization shown by the presentation of "indifferent" stimuli, and the small amplitude of the sharp inspirations

The failure to obtain a conditioned response as strong and stable as was the unconditioned one is not peculiar to the present experiment, but is typical of conditioning in general (13, 8, p 428-429) The conditioned responses obtained in the present experiments were somewhat weaker and less stable than those obtained with shock in some of the higher mammals (1, 12) which may perhaps be attributed to the fact that the rat has no very stable response that is adequate for dealing with a shock when the animal is restrained. A conditioned response involving actual flight from the locus of the shock may be established with relative ease (9) but the combination of shock and restraint is more apt to result in struggling than in precise foreleg withdrawal in the rat Apparently the foreleg withdrawal from shock is too intimately bound up with locomotion to be readily conditioned as a specific response (cf. 11)

We may now turn our attention to the unconditioned reaction to buzz or light, as observed before training. A consideration of the responses elicited by *B* or *L* during the pretesting sessions will indicate that either of these stimuli may elicit the same response as the shock. It should be noted, however, that *B* or *L* rarely elicits a strong reaction, the more typical response being a simple change in the breathing curve Even this slight response does not occur consistently and seems to drop out after a few presentations of *B* or *L*. But the mere fact that the new stimulus, before training, may occasionally elicit all the reactions that we hope to condition to it should be noted. Comparable statements may be made about many other types of conditioned response experiments For example, in the knee jerk (16) or the eyelid reflex (4), the to-be-conditioned stimulus may be shown to be in functional relationship with the unconditioned reflex through the demonstration of its facilitating effect on the latter. Indeed, it is possible that we could not establish a conditioned reflex at all unless there were already present some sort of a connection between the new stimulus and the unconditioned response. This does not mean that we are doing nothing by our conditioning procedure. There is a marked difference between the rat in which a *B* or *L* will release a squeal or struggle, when he is so excited that he is about to struggle anyway, and the rat in which the same *B* or *L* will regularly elicit a sharp inspiration, squeal, and leg withdrawal, even when he is resting quietly. A glance at the charts presented in this paper will show that our conditioning procedure brings about the change from a rat which is occasionally startled by *B* or *L*, to a rat which responds to them more or less as he would to the shock and brings it about in a fairly regular manner. But since the change is a gradual one, it is difficult to say just when conditioning has occurred Of course some arbitrary criterion could be established, but for present purposes it seems more satisfactory simply to indicate the changes that have actually been brought about by the training and not to decide exactly when an animal may be said to have developed a conditioned response.

3 *Conditioning Based on Foreleg Shock Compared with That Based on Tail Shock* A comparison of the results described in this paper, based on a foreleg shock, with those previously reported, which were based on a shock to the tip of the tail, will indicate that the results are not dependent in either case upon the particular withdrawal response elicited. Of course a tail shock results primarily in tail withdrawal instead of in flexion of the foreleg, but the breathing reactions, squeals, and even the general characteristics of the withdrawal itself are not very different. Indeed, even after studying the many thousands of reactions of each type reported in these papers, it is difficult to tell from the record proper whether a

given record was taken from the tail or the foreleg. The incidence of conditioning obtained during the two studies is about the same, when we have roughly comparable conditions of training, such as strength of shock, number of trials, etc

At this point it might be well to repeat that the tail *withdrawal* reported in the first paper is not the same response as the tail reaction recorded from rats X1-X4 The latter reaction is incidental to foreleg stimulation, is recorded from the tip of the tail, and may be considered part of the tonic background of the foreleg withdrawal. But the tail withdrawal reported earlier was a definite withdrawal of the base of the tail, involving a thrusting forward of the whole hind quarters of the animal, and is not comparable with the foreleg reaction reported in this paper.

4. *The Effects of the Short-Circuiting Contacts.* In the experiments with the tail withdrawal it was found consistently that it made little or no difference in the rate of conditioning whether or not the rat could terminate or avoid the shock by withdrawing the tail In the present experiments one rat of every experimental pair was trained with short-circuiting contacts arranged so that the first movement shorted the shock, while his experimental mate was trained without these contacts An examination of the charts will show that the only pair of rats in which there was a clear difference in incidence of leg responses between *SC* and *noSC* rat was the pair used in Experiment I. In this experiment it was the *noSC* rat (A0) that developed the leg withdrawal, despite the fact that the response did not terminate or prevent the shock We thus find no more indication that anything comparable to the "law of effect" is working in the conditioned leg reaction than we did for the conditioned tail reaction. Furthermore, when we did place the *SC* contacts in the circuit, after rat A0 had developed a consistent leg withdrawal, the response fluctuated in frequency of incidence, apparently undergoing periodic cycles of extinction and reinforcement. In other words, success in avoiding the shock led to extinction of the response instead of "stamping it in." This would seem to be an example of what Hull has referred to as "the dilemma of the conditioned defense reaction" (7). It has been avoided by some experimenters by never omitting reinforcement (12, 22, 23). Finch and Culler (2) have overcome the effects of such extinction by punishing their dogs with an extra shock (to the thorax) if they fail to respond. More recently (1), they have reported the use of what may be called a

substitute reinforcement, namely, a buzzer which always sounds when the shock is on, even though the dog may have his foot lifted, thus avoiding the shock This might seem to make the conditioned response a second order one with the buzz a first order conditioned response, and we should expect the same difficulties in extinction of the buzz-shock conditioned response we have found in the rat. However, James (10) has reported that conditioning in some dogs can be established more readily if the dog can avoid the shock. Apparently, then, animals higher than the rat can learn to avoid a shock by a specific foreleg flexion, while the rats cannot, at least in our present experiments.

5. *The Importance of the Strength of the Shock.* One of the most important factors in determining the development of conditioning is the strength of the shock. This was found to be true for the tail withdrawal, previously reported, and seems to be equally true for the responses based on a shock delivered to the foreleg It will be noticed that conditioning was much slower in those rats (A0, A1, C1, C2) that were started with a shock of 1 ma than *it was in those (A2, A3, X1, X2) that were started at .2 ma.* With the former animals, conditioning did not show a high incidence until the shock was increased in intensity to .2 ma. or more. Further, as *training progresses, the rats seem to "adapt" to the shock so that* it must be increased still further. In general, it may be said that a favorable strength for the shock during the early sessions is 2 ma , with a stronger value, perhaps as high as .4 ma. during the later sessions These values, of course, may be stated only for our present rats and apparatus They are about ten times the threshold But perhaps the best way to describe the strength of the shock is by the reactions it elicits. The shock should be strong enough to elicit a sharp and full leg reaction, accompanied by several loud squeals, but not strong enough to cause continued struggling. Conditioning might or might not be more rapid with a stronger shock, but the question cannot be decided because any conditioned reactions that occur under such conditions are confused with the background of struggling

6 *Experimental Extinction* Extinction sessions were given only to the four rats of Experiments I and II. Of these, the only one that had anything approaching a stable conditioned leg withdrawal was rat A0. After one buzz-shock stimulation, this rat showed a waxing and waning of the response during 10 unreinforced buzzes.

This would seem to be the same phenomenon noted in experiments reported by Switzer (21), and by Hilgard and Marquis (4), in which the conditioned lid response increases during the early part of an extinction session and falls off again toward the end We have noticed it occasionally during our experiments reported previously, but hesitate to stress it, in view of the instability of the conditioned responses obtained and especially since the rat is apt to be inactive during the early part of a session unless the "energizing" shocks are used.

Roughly comparable to the results obtained from this rat were those obtained from rat A3 The strength of the response waxed and waned irregularly throughout the extinction session, reaching a high point when, after 15 unreinforced *L*, three successive presentations of *L* resulted in inspirations, squeals, and leg pulls. With both animals there was a tendency for the responses to have a long latency during extinction

Rats A1 and A2 presented a different picture The first of these rats responded consistently to every presentation of the conditioned stimulus by an inspiration and squeal and showed no indications of extinction Rat A2 showed extinction only to the extent that the vocalized squeal dropped out, leaving the squeal pattern clearly visible at reduced amplitude in the breathing record We hesitate to draw any conclusions from the results of the extinction sessions, except to indicate that the breathing responses are very resistant to extinction.

7 *Importance of Other Factors.* We may profitably devote a little attention to a number of other generalizations made in the first paper of this series to see to what extent they seem to hold for the present experiments These remarks will be grouped into one section since we do not wish to stress them They should be considered as indications, rather than clear-cut conclusions

a. Relative effectiveness of buzz and light. It was suggested in the first paper of this series that the *L* was a less effective stimulus than *B* This was indicated by less frequent responses to the *L* before training, slower conditioning to *L*, and more spread, or generalization, from *L* to *B* than in the opposite direction No one of these three criteria shows a consistent difference between *B* and *L* in the present experiments For example, the two rats conditioned to *L* developed inspirations and squeals more rapidly than did any other rats We would hesitate to generalize from the results of these two animals and say that *L* was more effective than *B*, but we certainly have no indication that the opposite was true. We believe that the increased effectiveness of the light during the present studies may be attributed to the substitution of the polished metal hood used as a head cover in the present experiments, instead of the dark velvet cloth cover used in the earlier ones. The shiny cover may well have increased the effectiveness of the light.

b The importance of "tests." In the first paper of this series, some evidence was reported that a large number of unreinforced test presentations of the conditioned stimulus retarded conditioning. This would, of course, involve partial extinction. In Experiment III tests were completely omitted. The two rats of this experiment conditioned rather poorly. But we are not justified in attributing the unusually poor level of conditioning obtained in this experiment to the omission of unreinforced presentations of the conditioned stimulus, for a weak shock was used in training these animals. Razran (14) has pointed out that, in shock conditioning with human subjects, it is often necessary to omit the reinforcing shock for a time to obtain satisfactory conditioning. With animals, however, a number of experimenters (22, 23, 5, 12) have been careful never to omit the reinforcing shock, depending on early responses to indicate the level of conditioning. To make anything like a significant study of the influence of test presentations on the development of conditioning would involve another major investigation Every test presentation means either an increase in the number of stimuli presented during a session or a decrease in the number of reinforcements, and either of these changes might influence the rate of conditioning.

At any rate, it seems likely, from our present results, that three or four unreinforced presentations of the conditioned stimulus, distributed through each session, will not retard conditioning appreciably and will furnish extremely valuable data, not only in regard to the complete form of the conditioned response but also in regard to its incidence Early responses, as determined during double stimulation, furnish the most stable index of conditioning from a statistical viewpoint since the response to every double stimulation may be considered. But when there is the possibility that the conditioned response will be obscured by the unconditioned one, it would seem advisable to present occasional tests. In the present experiments such tests often show a conditioned leg reaction that is too slow to appear as an early response.

SUMMARY AND CONCLUSIONS

1. Each of 10 rats was restrained in a holder and subjected to from five to 20 conditioning sessions, or a total of 90-300 paired stimulations

2 A barely threshold shock to the foreleg resulted in slight changes in the breathing rhythm. As the shock was increased in strength, the response became more extensive, successively involving sharp inspirations, squealing, tail movements, leg withdrawals, and finally struggling.

3 Repeated paired presentation of a buzz (or light) with the shock gradually established a conditioned response As the conditioned response increased in strength and stability, it resembled, *in a rough way*, the response to stronger and stronger shocks. Thus the shifts in breathing rhythm appeared after a few stimulations Under favorable conditions the inspirations and squeals became stabilized after as few as 20 presentations. The most specific response, the foreleg withdrawal, was more refractory to conditioning since it became reasonably stabilized in only one of the rats, requiring seven sessions, or a total of 100 paired stimulations.

4 The inclusion of short-circuiting contacts so that the rat could prevent or terminate the shock by a leg withdrawal did not accelerate the conditioning process. The one rat that developed a stable withdrawal had been trained without the contacts. When they were added, the conditioned withdrawal suffered alternate "experimental extinction" and "reinforcement" rather than "stamping in by success"

5 The influence of strength of shock, extinction, test presentations of the conditioned stimulus, and the relative effectiveness of buzz and light are presented.

6. The results of the present study substantiate those already reported for the tail withdrawal.

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STUDIES ON THE VARIABILITY OF HANDWRITING. THE DEVELOPMENT OF WRITING SPEED AND POINT PRESSURE IN SCHOOL CHILDREN*

From the Hungarian Institute for Handwriting Research

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It has long been known that each handwriting shows individual traits and that no two persons write an identical hand It is also well known that individual differences are constant, so that each handwriting may be identified through its personal traits Graphology, or the science of handwriting, is based on this experience. Graphologists claim that writing varies not only with the individual, but also within certain limits with the circumstances influencing the individual. The variations of handwriting, thus, express the traits of the writer's personality. Expressive characteristics of personality are interesting material not only for the graphologist, but for various other branches of applied psychology and medical science In the course of previous psychological and clinical investigations an endless variety of handwriting was analysed, without affording a solution of the problem of individual variability and personal consistency.

There is but little information available as to the limits of variability; we do not know what variables are consistent or frequent, and which are still normal or already abnormal. Each handwriting is derived from a model, namely, from the letter forms of the school notebook, and a certain amount of time has to elapse until this uniform shape acquires at last some individuality. Hence the question arises· what influences bring about the changes during the development of handwriting? Does sex, age, physical and mental growth, or ill health affect the handwriting? Has sexual maturation any demonstrable effect on the curve of writing development?

The significance of these problems is both a theoretical and a practical one They affect several branches of applied psychology such as: constitutional research, psychiatry, pedagogy, psychotechnics (ability tests), etc., in short, all endeavors in which writing, as a

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direct or indirect test or subsidiary means of testing, is an essential factor in obtaining standards. These problems are of utmost importance to graphology, whose main task, consideration of the individual variability, demands interpretation in the light of objective research.

Hence the importance of these questions for law and legal procedure, *since the testimony of the* expert in court after examination of questioned documents uses the variability of handwriting (11) as a means for their identification.

The magnitude of the problem compels me to limit the material for the present discussion. This paper deals with the measuring of (1) writing speed (time) and, (2) point pressure.

I have constructed a special apparatus, the "graphodyn" to serve this purpose The "graphodyn" enables us to record tracings which illustrate (1) the time required for writing, and (2) the degree of pressure exerted on the point of the stylus.

The data for our investigations were obtained by measuring schoolboys and schoolgirls from 11 to 18 years of age. (Children over the age of 10 years and 6 months count as 11; over the age of 11 years and 6 months as 12, etc.)

On this basis, these examinations were made to answer the question: what is the meaning of the curve obtained at various stages and at puberty, and what differences are observed between normal *and abnormal individuals*

My observations are based upon repeated measurements made over a number of years continued since 1931. Most of the tests were performed at the Berzsenyi Daniel High School of Budapest, in which the Hungarian Institute for Handwriting Research is located. Our curves record the growth in writing speed and pressure of the individual children over a period of years. Similar experiments were made also with homogeneous groups of schoolboys and schoolgirls from other schools. As the latter have been measured in single sessions only, the averages for the different years were not made up always from the same children But a comparison of our mass statistics with the individual curves confirms their reliability

2145 children were tested separately according to age and sex, as summarized in Table 1. Obviously ill or abnormal individuals were not included, hence the investigated material can be considered as

Table 1

SEX AND AGE DISTRIBUTION

AGE	♂	♀	TOTAL
11 YEARS	118	125	243
12 "	121	124	245
13 »	133	140	273
14 "	133	145	278
15 »	118	127	245
16 »	147	118	265
17 "	137	140	277
18 »	183	136	319
TOTAL	1090	1055	2145

normal as far as looks, perception, and social behavior are concerned.

All the tests were made under practically identical conditions, always by the same, well-trained persons under my personal supervision. The data obtained were checked by previous experiences and the reliability of unexpected deviations was controlled by repeated measurements.

The graphodyn (14), the instrument we employ for measuring, carries a stylus slightly heavier than a fountain pen Anybody can write with it in his ordinary way. The apparatus is worked with a lever, the writing lead at its shorter end while its longer end is fixed to a small tambour. During the actual process of writing, the actual point pressure affects the air-filled tambour. The latter is connected through an air system with the registering kymograph on which graphic records are obtained. The rubber membrane of the tambour, though exceedingly sensitive, may be used for several days' tests. As a standard article, it can be easily replaced in case of a leak. Minor inaccuracies due to external circumstances (such as air pressure, etc.) are negligible in our experience Application of weights to the apparatus, increasing from 20 grams to 1600 grams, did not materially change the results of the tests within the limits of permissible inaccuracy (0.1)

Registration of our tests was standardized, so that 200 grams of pressure on the stylus were recorded by a rise of one millimeter, while the peripheral speed of the kymograph corresponded to 10 millimeters running length per second

The person subjected to the test was instructed to write at his most convenient speed and pressure, his first and last name, then twice the name of his domicile (Budapest) and to finish with the same, well-known patriotic slogan. We found the use of the word "Budapest" most practicable, for it could be perceived by everyone with the same ease and thus be considered as a standard word in making evaluations (Figure 1).

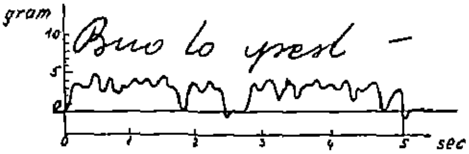

FIGURE 1
GRAPHODYN TRACING OF THE WORD "BUDAPEST"
(Enlarged) Time in seconds Point pressure in grams.

The recording needle, raised by any change of pressure, traces a continuous curve on the moving band of the kymograph as an illustration of the writing process. There are extraordinary individual differences in height and length, general form and regularity of these tracings. The various peaks, the differentiation and order of periods, precisely determine the points at which change of speed and pressure takes place Analysis of the tracings shows the time required for the writing, expressed in the values of the abscissa, while the values of the ordinates represent the point pressure. On the time axis one millimeter corresponds to one second; on the pressure axis one millimeter to 200 grams. The measuring of the axis is done by means of a magnifying lens, up to 0.1 millimeter exactitude. The highest peak on the tracing indicates the maximum pressure The average pressure is determined by measuring the height of all peaks and by dividing their sum total by the number of peaks measured After obtaining these measurements, we computed the average, the standard deviation, the coefficient of variation, and the probable error for each series. Space does not permit reproduction of our entire material, which is kept for reference in the files of the Hungarian Handwriting Research Institute

General Results

Distribution and Norms. The examination of writing speed and point pressure in Hungarian schoolboys and schoolgirls was carried out in separate series for both sexes and every year of age from 11 to 18. The distance of the unit of standard deviation (sigma) was laid off twice on each side of the arithmetic mean (M). Approximately 95.5 per cent of all the cases were found within this range This normal distribution directly determines also the normal zone, which, calculated in sigma scores is marked $M = 2\sigma$. The majority of cases (95 per cent) falls within the normal zone, these are the normal cases. Approximately 4.5 per cent of the observations are found toward both ends of the range these are the extreme cases

In Tables 2*a* and 2*b* the percentages are presented Nearly two-

Table 2/A.

PERCENTAGE PARTITITION THROUGHOUT THE NORMAL ZONE BASED ON STANDARD DEVIATION.

SPEED

AGE	←		NORMAL ZONE						→	
	QUICK		$+2\sigma$ BORDER		$+\sigma$ M $-\sigma$ AVERAGE		-2σ BORDER		SLOW	
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
11	2·6	–	17·0	13·6	60·2	66·4	17·8	15·2	2·4	4·8
12	5·4	–	17·3	19·0	55·4	66·5	12·5	11·2	9·4	4·3
13	0·8	5·7	14·4	23·6	66·7	46·4	16·6	10·0	1·5	14·3
14	0·8	–	9·8	16·6	74·3	66·3	11·3	13·0	3·8	4·1
15	–	3·2	11·9	11·7	73·8	70·1	10·1	9·5	4·2	5·5
16	0·7	–	17·0	16·3	65·2	69·2	14·3	12·7	2·8	1·8
17	–	0·7	15·9	13·6	69·7	68·4	8·2	13·0	6·2	4·3
18	–	0·7	10·9	7·4	76·6	80·8	12·5	11·1	–	–

Table 2/B.

PERCENTAGE PARTITITION THROUGHOUT THE NORMAL ZONE BASED ON STANDARD DEVIATION.

POINT PRESSURE

AGE	← HEAVY PRESSURE		NORMAL ZONE $+2\sigma$ BORDER		$+\sigma$ M $-\sigma$ AVERAGE		-2σ BORDER		→ POOR PRESSURE	
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
11	5·0	5·6	12·6	12·0	65·0	72·0	17·4	10·4	–	–
12	5·0	5·6	11·5	10·5	64·6	75·1	18·9	8·8	–	–
13	3·8	4·3	13·7	15·7	64·1	61·4	18·4	18·6	–	–
14	6·1	7·9	11·4	12·9	68·9	66·4	13·6	12·8	–	–
15	5·8	4·2	16·7	11·6	60·0	67·5	17·5	16·7	–	–
16	6·2	2·8	8·3	13·9	71·1	63·9	12·3	19·4	2·1	–
17	5·2	4·4	10·5	12·5	64·2	65·4	20·1	17·7	–	–
18	4·9	3·1	13·6	13·7	64·0	69·5	17·5	12·9	–	–

thirds of the cases are grouped near to the mean and represent the average ($M = 1\sigma$). The remaining third is grouped about the peripheries of the normal zone ($M = 2\sigma$) and represents the border line cases. Among these, as to writing speed, the slow variations are much more frequent, and as to pressure, the heavy variations *Extreme cases are rare; their tendency is toward slow speed and heavy* pressure

Table 4 shows the frequency curves for speed and pressure, one curve for each year of age from 11 to 18

SPEED

1. *Variability.* The range of the series is wide and varies with age It is widest at the age of 11 with a decrease in each subsequent year. Variability, as a general rule, is less in girls than in boys up to the age of 18, when the ranges tend to become equal. After the age of 14 years the minima (greatest speed) were recorded with girls while the boys reached their maxima of slowness

2. *Coefficient of Variation.* As shown in Table 3*a*, the figure of relative variation with boys is about 24-17, and with girls about 22-17.

Table 3/A.

$$V = \frac{\sigma}{M} 100$$

Time		
AGE	♂	♀
11 YEARS	22·5	22·4
12 „	17·8	17·1
13 „	22·1	15·0
14 „	24·0	19·3
15 „	19·5	18·1
16 „	18·9	16·9
17 „	16 9	18·5
18 „	18·2	20·8

3 *Changes of the Averages with Age* Both sexes show the highest arithmetic means at the age of 11, after which a gradual decrease of the means is recorded with the annual development of writing speed. The most significant change occurs from the age of 11 to 14.

Table 3/B.

$$V = \frac{\sigma}{M} 100$$

Pressure		
AGE	♂	♀
11 YEARS	42 9	48·0
12 „	35 7	42 5
13 „	40·0	34·7
14 „	42·2	43·6
15 „	38·3	37·2
16 „	37·9	35 3
17 „	36·2	37·7
18 „	34·1	34·3

Table 2/B.

PERCENTAGE PARTITITION THROUGHOUT THE NORMAL ZONE BASED ON STANDARD DEVIATION.

POINT PRESSURE

AGE	← HEAVY PRESSURE		NORMAL ZONE $+2\sigma$ BORDER		M $+\sigma$ AVERAGE $-\sigma$		-2σ BORDER		→ POOR PRESSURE	
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
11	5·0	5 6	12·6	12·0	65 0	72·0	17·4	10·4	–	–
12	5·0	5·6	11·5	10 5	64·6	75·1	18·9	8·8	–	–
13	3·8	4·3	13·7	15 7	64 1	61·4	18·4	18·6	–	–
14	6·1	7·9	11·4	12·9	68·9	66·4	13·6	12 8	–	–
15	5·8	4·2	16·7	11·6	60·0	67 5	17·5	16 7	–	–
16	6·2	2·8	8·3	13·9	71·1	63·9	12·3	19·4	2·1	–
17	5·2	4·4	10·5	12·5	64·2	65·4	20·1	17·7	–	–
18	4·9	3·1	13·6	13·7	64·0	69·5	17·5	12·9	–	–

thirds of the cases are grouped near to the mean and represent the average ($M = 1\sigma$). The remaining third is grouped about the peripheries of the normal zone ($M = 2\sigma$) and represents the border line cases. Among these, as to writing speed, the slow variations are much more frequent, and as to pressure, the heavy variations. Extreme cases are rare; their tendency is toward slow speed and heavy pressure.

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SPEED

1 *Variability.* The range of the series is wide and varies with age It is widest at the age of 11 with a decrease in each subsequent year. Variability, as a general rule, is less in girls than in boys up to the age of 18, when the ranges tend to become equal. After the age of 14 years the minima (greatest speed) were recorded with girls while the boys reached their maxima of slowness.

2. *Coefficient of Variation.* As shown in Table 3*a*, the figure of relative variation with boys is about 24-17, and with girls about 22-17.

Table 3/A.

$$V = \frac{\sigma}{M} 100$$

Time		
AGE	♂	♀
11 YEARS	22·5	22·4
12 „	17·8	17·1
13 „	22·1	16·0
14 „	24·0	19·3
15 „	19·5	18·1
16 „	18·9	16·9
17 „	16·9	18·5
18 „	18·2	20·8

3 *Changes of the Averages with Age* Both sexes show the highest arithmetic means at the age of 11, after which a gradual decrease of the means is recorded with the annual development of writing speed. The most significant change occurs from the age of 11 to 14.

Table 3/B.

$$V = \frac{\sigma}{M} \cdot 100$$

Pressure		
AGE	♂	♀
11 YEARS	42·9	48·0
12 „	35·7	42·5
13 „	40·0	34·7
14 „	42·2	43·6
15 „	38·3	37·2
16 „	37·9	35·3
17 „	36·2	37·7
18 „	34·1	34·3

Speed increases more slowly after this period than in previous years: on the average, about 40.4 per cent with boys and 47.9 per cent with girls. There is a slowing down of this progress at about the age of 15. From 16 to 18 the speed again tends to increase slightly: about 14 per cent with boys and 9.1 per cent with girls (Table 5*a*).

The frequency curves at the age of 14 and even more so at the age of 11 exhibit two maxima, from which we infer that children at this age do not constitute a homogeneous group. A study of the individual curves shows that cases of infantilism at the age of 11 and cases of retarded pubescence at the age of 14 disturb the homogeneity of these groups.

4. *Development.* The rectilinear course of development runs upward with increasing years. At the age of about 13-14 all technical difficulties of writing are overcome; writing has become a well-controlled activity, and speed can now develop freely. The specific writing speed (8) corresponding to the quick or slow character of the personal speed becomes now constant. Disregarding certain fluctuations at the period of puberty, the writing speed hardly changes during the following years. Then at 14, the average boy has reached almost 85.4 per cent and the girl 99.1 per cent of the writing speed they will display at the age of 18.

5. *Sex.* The writing speed of boys and girls is about equal at the age of 11. During the following two years the average girl writes quicker than the average boy, but the difference is indefinite. At 14, however, the writing speed of the boys is always inferior to that of the girls (8), since the difference of their means is more than three times the probable error. Thereafter the difference in speed between the two sexes is gradually decreasing (Table 5*a*). Equality is reached at about the age of 18. Individual studies reveal that the maximum spurt in the development of speed does not always occur at the same age. It sets in most commonly around the age of 13 with girls and 14 with boys. The precocity of girls in attaining a mature writing speed seems to be established. It is a fact that puberty gives a special impetus to writing speed, while further development of speed terminates with sexual maturation.

6. *Normals.* The majority (two-thirds) of our material can be classed as the average normal. The border-line and extreme cases were subjects of special investigations. We found no reason to assume that departure from the average in the direction of quick

TABLE 4

FREQUENCY CURVES

Distribution of writing speed and point pressure; one curve for each year from 11 to 18

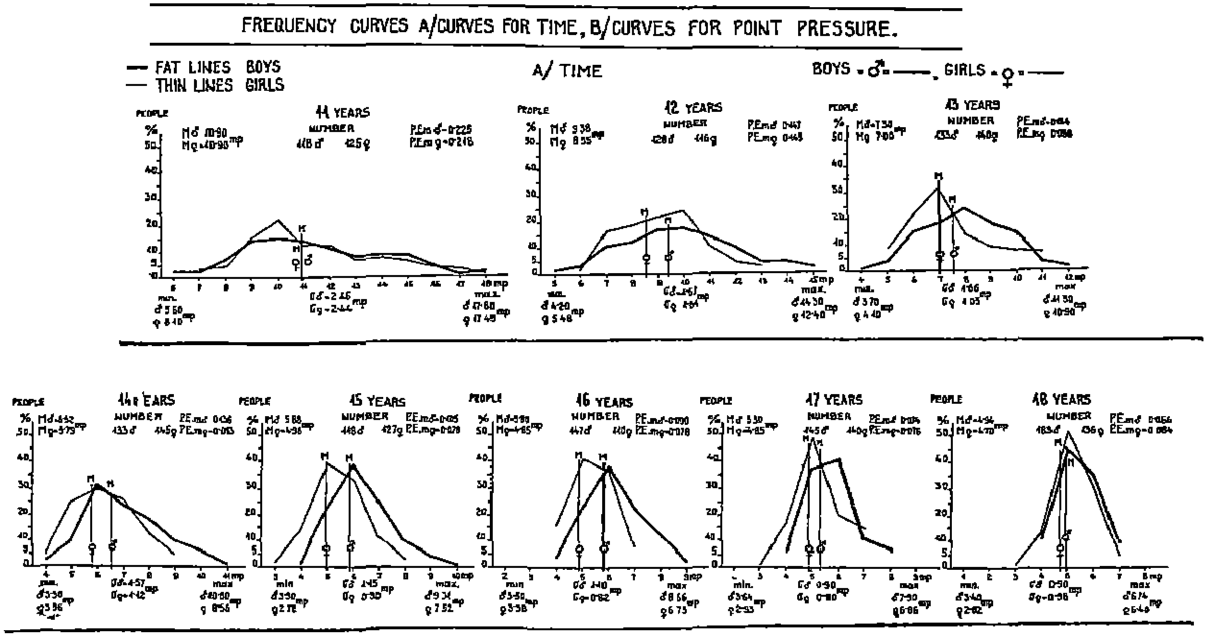
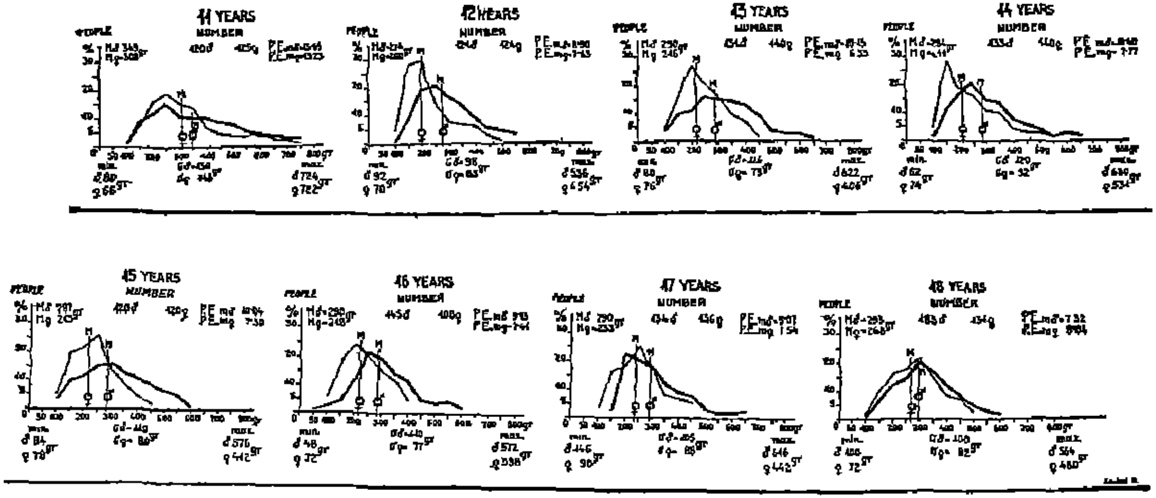


TABLE 4 (*continued*)

B/ PRESSURE



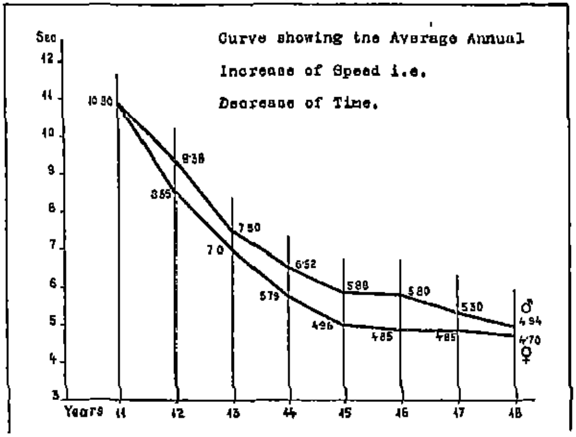
speed expresses mental alertness or precocious development. Some of the extreme cases, however, gave evidence of endocrine disorders, such as hyperthyroidism Deviation towards slowness on the other hand, seems to be characteristic of mental sluggishness—or general retardation The extreme cases of slow speed were found to indicate thyroid failure or some major disorder of mental or physical development.

POINT PRESSURE

1. *Variability.* The range of the series is wide and varies with age It is widest at the age of 11, gradually decreasing thereafter. It is a general rule that the range of variability is less in girls than in boys, except for the youngest group of 11 years of age (11), when no differences whatever were found

From 12 years on the maxima are always reached by boys, and the minima by girls, except for the age groups of 15 and 17, when the boys show the poorest pressure (50 grams)

Table 5/A.

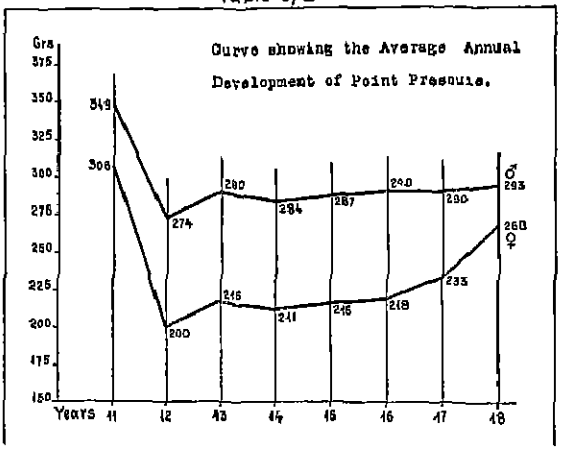


2 *Coefficient of Variation.* According to Table *3b,* the figures of relative variation range from 42 9 to 34.1 with boys and from 48 to 34.5 with girls.

3. *Changes of the Average with Age* Both sexes reach their highest arithmetic mean at the age of 11 years; at 12 years comes a striking decline, 21 5 per cent with average boys and 48.6 per cent with

girls. This stage is followed by a rise in pressure until the latter becomes steady at the age of 13, and with boys, the same average height is reached at that age as found in boys of 18. With girls the average height obtained remains unchanged only for a few years. Then a new rise sets in until the maximum pressure is reached at the age of 18 (Table 5*b*)

Table 5/B



A less harmonious distribution than during other years accounts for the extreme values and the grouping of the curves of boys at 16 and 17, and of girls at 14, while writing pressure shows a definite tendency to fall below the normal average

4 *Development.* In the course of development, fluctuations and a tendency to decreased pressure is noted The technical difficulties of writing are solved at or about the age of 13, hence the general muscular tension of the individual manifests itself as the specific writing pressure. It is significant that the average writing pressure of a boy of 13 is approximately the same as that of a boy of 18, consequently the writing pressure is not likely to be due to the raw muscular force of the hand, but is dependent on the general muscular tension (4).

A most remarkable break in the course of development occurs with boys at the age of 16 and 17, and with girls, though less pronounced, at 14. It is a remarkable and hitherto overlooked fact that in these stages a marked tendency arises toward poor pressure. This phenomenon is of especial importance, and deserves further studies.

5. *Sex.* There is no difference in writing pressure between boys and girls at the age of 11. In the following years (12-14), however, the girls' writing pressure is less than the boys' The difference in the mean is more than three times the probable error. The difference decreases slightly at the age of 15, increases again at 16 and 17, and ceases to be significant at 18, when neither writing speed nor pressure shows any difference in the two sexes.

The age of 13 is the turning point with the average boy; pressure becomes stabilized at the same level that is characteristic for boys of 18 In the postpubertal stage, however, pressure suddenly tends to fall below this level. There is a minimum at about 16 or 17 years, followed by a sudden return to the higher level.

The growth of writing pressure in girls is not terminated at 13. After a temporary pause, the increase continues up to the age of 18 It seems that boys precede girls in attaining the mature writing pressure, while the girls lead in speed, as stated above

6. *Norms.* About two-thirds of all the records approach the average A study of the border-line and extreme cases shows that pressure depends on the amount of "effort" spent in writing (4) Pressure is increased by a lack of manual skill, exertion to overcome physical or mental handicaps, or by excessive excitability.

Heavy pressure makes coordination more difficult and slows down writing speed The heaviest pressure, combined with slowness, was observed in problem children, masked stutterers, and in cases of infantilism. Efficiency of writing is generally favored by low pressure (4), as seen in fast, mentally alert writers or in hyperactive, easily tiring individuals

We could hardly record any cases of extremely poor pressure among the normal group of schoolboys and schoolgirls Out of 2000 children tested, only an insignificant number of boys 17 years of age had an abnormally low pressure

INDIVIDUAL CASES

This study attempts to approach our problems by statistical methods. It might not be amiss to supplement these data with some individual cases that show how the development of their writing is in accord with the above presented mass statistics

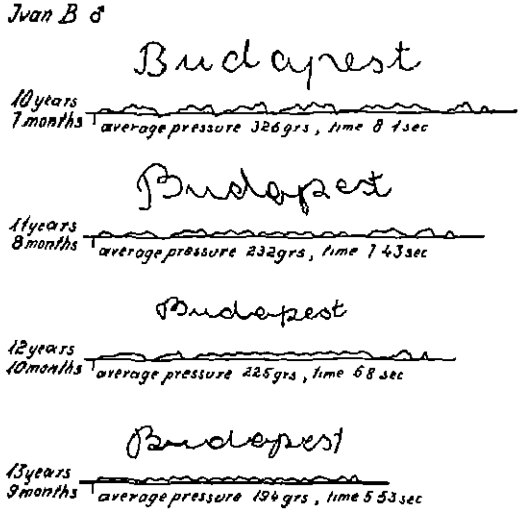


FIGURE 2

Graphodyn tracings of the word "Budapest" The tracings show the annual decrease in the running length (increment of speed), and annual decrease of height (decrease of pressure).

Figure 2 reproduces four original graphodyn tracings. These records were taken at various times of a boy from 11 to 14 years of age. Height and length of these tracings are quite different. Their running length diminishes from year to year and their height also shows a gradual decrease, expressing the changes in writing speed and point pressure The measured values, running fairly close to average for the respective age groups, demonstrate the annual decrease of time, i.e., *increase of* speed, and the decrease of pressure.

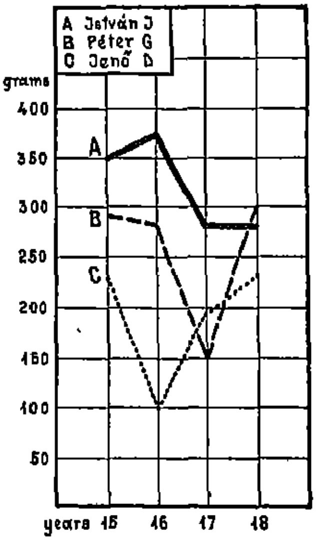
Table 6 represents the development in point pressure of three boys between the ages of 15 and 18 The writing pressure is breaking down abruptly in the course of one year. The age at which this breakdown occurs varies, according to our studies, between 16 and 18 years and characterizes the postpubertal stage. Writing pressure rises again with almost explosive velocity after that critical period and becomes stabilized at the average level.

DISCUSSION

Our investigations have established standard values of writing speed and point pressure which can be utilized as an index of matura-

TABLE 6

DEVELOPMENT CURVES FOR POINT PRESSURE



tion and mental growth. In order to prove the practical value of these standards, I wish to report our experiences in the study of abnormal children. This control group consists of 600 individuals and includes 100 stutterers, 43 deaf mutes, 46 backward children from an ungraded school, and 77 juvenile delinquents committed to a corrective institution These studies, especially with reference to speech defects, have been previously reported on in great detail (6, 7, 13, 14). Tables 7*a* and 7*b* show the precentages of abnormal subjects in nor-

Table VII/A. PERCENTAGE PARTITITION OF ABNORMAL GROUPS

SPEED

		NORMAL ZONE ←M→			
	QUICK	+2σ BORDER	+σ −σ AVERAGE	−2σ BORDER	SLOW
♂ STUTTERER	2 0	12 0	52·0	17 0	17 0
AND DEAF MUTE	6·9	16 2	34 7	9 2	33·0
♀ BACKWARD	–	2 2	4 4	23 9	69·5
♂ JUVENILE DELINQUENT	1 3	–	28 6	19 4	50·7

Table VII/B. PERCENTAGE PARTITITION OF ABNORMAL GROUPS

POINT PRESSURE

		NORMAL ZONE			
	←	+2σ	+1σ M σ	-2σ	→
	HEAVY	BORDER	AVERAGE	BORDER	POOR
♂ STUTTERER	24 0	16·0	43 0	17 0	—
AND DEAF MUTE	16 2	21 0	46·6	16 2	—
♀ BACKWARD	15·2	21·7	26 1	34 8	2 2
♂ JUVENILE DELINQUENT	1·3	—	41·7	45 4	11·6

mal and abnormal classes. A reference to Table 2, in which the percentages of normal subjects are indicated, will show (Tables 7*a* and 7*b*) the difference.

Stutterers. *Investigating a group of 100 stutterers, 85 mentally* normal boys, and 15 girls of 11 to 18 years of age, we find that their percentages throughout the normal zone are different from the normal group Extreme cases are numerous 19 per cent in speed and 24 per cent *in pressure. Of the remaining normal cases comparatively* few represent the average. 50 per cent in speed and even less in pressure.

Our tests have shown in this group a prevalence of the same characteristics. *poor performance, heavy pressure, retarded speed* Stutterers whose speech defect was serious showed, in conformity to their general motor behavior (7, 15, 16), unusually heavy point pressure, while their speed was slow and irregular. In less serious cases, where the person was able to converse fairly fluently, the pressure was lower After correction (13, 15) of the speech defect, pressure relaxes, usually approaching the average Blunderers, on the other hand, write very fast with poor pressure

Deaf-mutes *In a group of deaf-mutes* (21 boys and 22 girls) between the ages of 11 and 14 by far more numerous extreme cases were found. 40 per cent in speed and 16 2 per cent in pressure. The frequency of average cases is less than among normal children· only 24.7 per cent *in speed and* 46.7 per cent in pressure.

While the majority of deaf-mutes write rather slowly, some extreme cases were observed (7 per cent) who wrote much quicker than normal children of the same age. The high writing speed of these deaf-mutes does not further develop, but declines in the following years, with increasing intelligence their physio-psychological defect develops into a greater handicap The distribution of the frequency curve shows that the quick and slow elements form two entirely separate groups, proving their heterogeneous character

Juvenile Delinquents A group of 77 girls 14 to 18 years of age committed to a corrective institution shows an especially interesting distribution. There are less average cases in this group than among normals 28 6 per cent in speed and 41 7 per cent in pressure. The other cases tend toward slow speed and poor pressure Extreme cases are very numerous.

Extreme sluggishness of writing speed was observed in 50 7 per cent This is well in accord with the mental acuity level of this group which is considerably below the average. There was retardation of pubescence as well as of mentality in quite a few cases (12, 16, 20). In regard to pressure, the following difference was noted between the normal and the delinquent girls· in the delinquents, poor pressure was found in 11 6 per cent while out of 1000 normal girls not a single case of poor pressure was recorded In addition, there were 45.4 per cent border-line cases of low pressure. This compares with the 14 per cent border-line cases in our normal controls, while poor pressure was never observed in our control group of 1000 girls. Hence the conclusion is justified that lack of normal pressure is characteristic of the delinquent girls. To check up on our data, we subsequently investigated the inmates of other corrective institutions and found there even more extreme cases of poor pressure.

Only one girl showed extremely high pressure, she proved to be a highly excitable psychopathic person Attention was paid to the type of these girls also from a social point of view It was noted that poor pressure (4, 20), denoting lack of morale and will-power, was especially characteristic for those girls who were committed for "sexual offenses" The same applies also to the "aggressive" group, including girls without poise and balance who are in continuous conflict with the accepted rules of conduct (4). This group included many psychoneurotic, hysterical, or hypogonadal individuals.

Finally the ambiabnormal cases should be mentioned, in which both speed and pressure are extreme These subjects are not amen able to adjustment with much success Prognosis is especially unfavorable if sluggishness is combined with extremely poor pressure. This combination is rather paradoxical, as slower writing is generally correlated with heavy pressure.

Backward Children Forty-six children of an ungraded school, whose ages varied from 11 to 17, presented the most obvious departure from the normal (14). Only a few cases (4 per cent) have reached the average, while the vast majority falls outside the normal zone. As to speed, we notice 70 per cent to be extremely sluggish, and all the border-line cases except one show slow speed. The pressure in 16 2 per cent of the extreme cases was heavy; this includes numerous border-line cases. The fact that physical strength has no bearing on writing pressure is borne out again by these backward children who, poor in health and with weak muscles and underdeveloped carpal bones, write with extremely heavy pressure. Only two children of the whole group showed normal average performance, both as to speed and pressure One of these two was actually mentally normal, and his progress had been retarded only by some physical handicaps.

CLINICAL CASES

The reported studies demonstrate that variations of writing speed and point pressure are associated with age, sex, development, maturation, and other expressive personal traits. If this be so, the question arises whether writing speed and pressure are purely quantitative factors which have to be recorded by a mechanical instrument and expressed by mathematical figures, or whether they can also be considered as qualitative characteristics, apparent from the ordinary handwriting This question can best be answered by citing concrete examples.

I present, therefore, two clinical cases[1] in which marked changes of writing coincided with the onset of puberty.

Case I. N.E., 12 years and 6 months of age Clinical diagnosis· adiposo-genital dystrophy. Patient's script before treatment (Figure 3*a*) is neat, sticks to the letter forms of school penmanship. An observer, trained in the estimation of writing speed, easily recognizes the extreme slowness of his performance The whole motion

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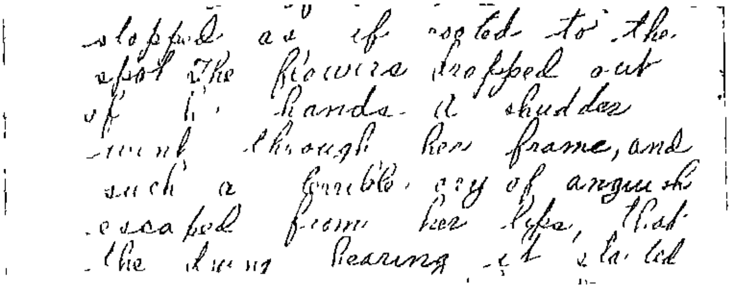
[1] I am obliged for the case records to M A. Goldzieher, M.D , of New York.

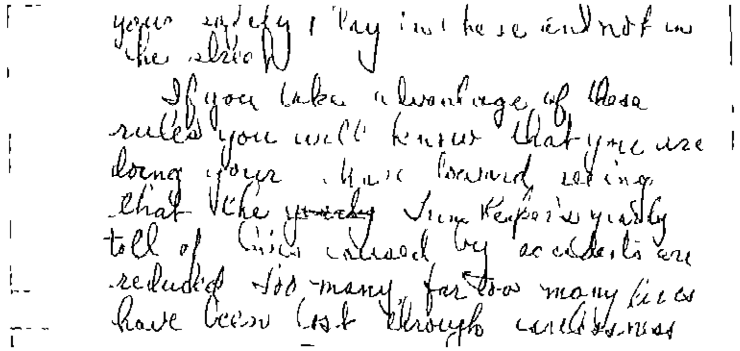


stopped as if rooted to the
spot The flowers dropped out
of her hands A shudder
went through her frame, and
such a terrible cry of anguish
escaped from her lips, that
the [illegible] hearing it [illegible]

FIGURE 3*a*

Handwriting of patient I before treatment Retarded puberty Childish script

is slow, and slows down even more toward the end of each word, to stop completely upon the termination of each word impulse Writing pressure seems to be heavy, though within the limits of the border-line zone All told, the writing bears the characteristics of the school child's hand, the mental effort concentrating on penmanship rather than on the subject matter



your safety I play in here and not in
the street

If you take advantage of these
rules you will know that you are
doing your share toward saving
that the ~~yearly~~ Time Keeper's yearly
toll of lives caused by accidents are
reduced too many far too many lives
have been lost through carelessness

FIGURE 3*b*

Handwriting of patient I six weeks later Onset of normal sexual development, script more mature, typical of puberty.

Figure 3*b* shows the patient's writing after 6 weeks of pituitary organotherapy There was a weight loss of 17 pounds during this period, with rapid development of the genitalia and the appearance of pubic hair. Without going into details of handwriting analysis, we may enumerate the following characteristics the writer is driving his pen at full speed, *with the rhythmic alternations of medium* pressure, he writes with marked "sentence impulse", he overcomes the compulsions of the notebook, omits details, leaves loops unfinished, or exaggerates their size, the pattern of handwriting, its total graphic character is changed, it is no longer a neat, careful, infantile handwriting, but a careless longhand, penned with the unbalanced writing motions of the youngster who "runs wild" at the stage of puberty

Case 2 S K, boy, 13 years of age, left handed and stutters Clinical diagnosis: "adiposo-genital dystrophy" Figure 4*a* shows the

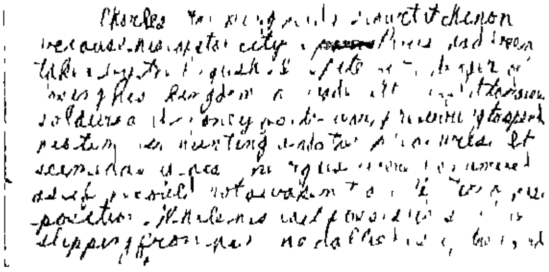


FIGURE 4*a*

Handwriting of patient II before treatment Retarded puberty, left-handed stutterer Childish script showing lack of coordination characteristic of stutterers

jerky, inhibited script of a stuttering child In spite of its obvious abnormalities, and the lack of coordination, it is, as a whole, childish and conventional. Administration of pituitary organotherapy was followed by marked development of the genital organs and signs of pubescence such as the beginning growth of pubic hair At the same time the script (Figure 4*b*) becomes disorderly, "muddy," and confused As his manual skill did not improve, he has trouble in keeping up the increased writing speed Instead of his previously deliberately controlled slow movements, he writes with a jerky hand and reveals the difficulties he has to overcome with each word which he starts to put on paper The pattern of the script indicates a lack of balance characteristic of the emotional instability of puberty

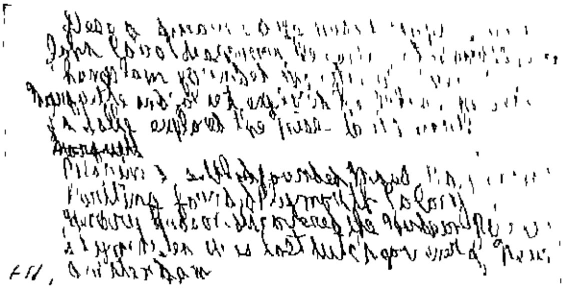


FIGURE 4*b*

Handwriting of patient II in the course of treatment Onset of puberty, script more mature, lack of balance expressing emotional lability of puberty

SUMMARY

A survey of the variations in writing speed and point pressure in 2145 Hungarian school children of 11 to 18 years of age is presented The data were obtained by measurements with the graphodyn, and evaluated by statistical methods These statistics offer detailed information about the variability of writing speed and point pressure in the different ages, and establish the occurrence of annual changes, and the effect of puberty upon the development of writing

These mass statistics are supplemented with individual case records, which, roughly, run parallel with the average normal

A normal zone is ascertained with special emphasis, as this enables us now to distinguish abnormal variations

A group of abnormal children. 100 stutterers, 43 deaf-mutes, 77 juvenile delinquents, and 46 backward children, has been investigated. The variations observed are in accordance with the abnormality of these children The quantitative factors of writing speed have, therefore, become significant in the study of children

Two clinical cases of retarded puberty are reported Comparison of the handwriting before and after medical treatment gives evidence that the onset of sexual development is accompanied by coordinate deviations in the curve of writing development

Variations of writing speed and pressure are quantitative and qualitative traits associated with, and related to, personality

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THE RÔLE OF DOMINANCE IN THE SOCIAL AND SEXUAL BEHAVIOR OF INFRA-HUMAN PRIMATES: IV THE DETERMINATION OF HIERARCHY IN PAIRS AND IN A GROUP*[1]

From the University of Wisconsin Primate Laboratory

A H. MASLOW

I INTRODUCTION

The purpose of this paper is fourfold (1) to check previous experiments reported in this series of papers (1, 5) using better controls, (2) to determine a hierarchy of dominance by interpairing all the animals of a group, (3) to compare the behavior of these paired animals with the behavior of the same animals in larger groups, and (4) to make a preliminary exploration-study of the effect of starvation on dominance behavior.

II ANIMALS, TECHNIQUE, APPARATUS, PROCEDURE

1. *Animals* Six rhesus macaques were used in this experiment, of which one died after the second series of interpairings Weight, size, and sex of the animals are given in Table 1 These animals are as closely matched as is usually possible when they are obtained from a dealer They are all of the same species and approximately of the same weight[2] and age It was impossible to get six animals of the same sex, although this had been desired A few of the pertinent facts about each animal will now be summarized

The importance of such an individual consideration will be pointed out below. They will be discussed in the order of their dominance in the pairings, the most dominant animal being described first, and so on.

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*Accepted for publication by Carl Murchison of the Editorial Board and received in the Editorial Office, December 20, 1935

[1] I wish here to express my thanks to Miss Kathryn Steiner and Miss Naomi Bernstein for their help in handling the animals, feeding them, etc, during the first half of the experiment

[2] It will be demonstrated below that closer similarity in weight would have been desirable

a. Blue. Male. The biggest and heaviest animal of the six. Paired twice before he died and completely dominant in both pairings.

b. Whitey Male Subordinate to Blue, not certainly dominant over Naomi, and certainly dominant over Christy, Red, and Kathryn, although not very positively. Relatively lacking in dominance expression, generally dominance was given to him rather than being asserted by him. Relatively afraid of and disturbed by the experimental situation Very quiet animal and did not resent overmuch (in his behavior), attempts by his subordinate partners to behave in a dominant fashion. Not very strongly driven by hunger except in spurts. Not strongly driven to sex behavior even when completely dominant (as in pairing with Kathryn). Completely and abjectly subordinate to Blue in their pairing The general impression is of an animal with a not very strong dominance drive, who is quite ready to take up subordinate rôle at any time, but who is given dominance status because his superior size makes his partners even more subordinate in their behavior

c. Naomi. A female who reached puberty during the course of the experiments. Unfortunately the services of an endocrinologist were not available and we have, therefore, no concomitant data on her sexual cycle. While we attempted to determine when she was in heat by the state of her sexual skin, breasts, etc, we were not expert enough to do this in any trustworthy fashion. Her heat periods must then be treated as an attenuating factor in our correlations There is no doubt that she behaved differently at different times (behaving like the typical female in heat) but we were not able to demarcate these periods at all clearly. Her drive to dominance seemed fairly strong In the pairing with Whitey her urge to dominance was obvious. She was ready to take up this status at any and all times Since Whitey was not a "dominance-expressive" animal, she was able to do this often. Her appetite for food seemed to fluctuate considerably. It will be noticed that she presented frequently in the pairing with Red even though she was completely dominant. She seemed to be in heat during the first five or six periods, and most of these presentations came at this time.

d Red. Male Dominant over Christy and Kathryn, subordinate to Blue, Whitey, and Naomi. An average animal, com-

TABLE 1*

ANIMALS NAMES, SEX, WEIGHT, AND CLASSIFICATION

	Names	Sex	Weight 3/17/35	Species
1	Blue	Male	8′ 15″	Macacus rhesus
2.	Whitey	Male	8′ 10″	“ “
3	Naomi	Female	6′ 10″	“ “
4	Red	Male	6′ 11″	“ “
5	Christy	Male	6′ 5″	“ “
6	Kathryn	Female	5′ 4″	“ “

*Animals are arranged in descending order of dominance. Blue was most dominant, Kathryn was least dominant

pletely dominant when dominant and completely subordinate when dominated When paired with overlord low in dominance expressiveness (Whitey), typically showed dominance behavior whenever this was made possible by Whitey's tolerance.

e. Christy Male Dominant over Kathryn, and subordinate to all the others. Dominance over Kathryn only fairly complete Never completely subordinated; showed *some* dominance behavior in all of his pairings, even when in subordinate status

f Kathryn A female, the youngest and smallest of the six animals. Very strong drive to dominance, although, because of size, had to occupy subordinate status in all her pairings. May be expressed by saying that she seemed to expect subordinate status and accepted it as a matter of course, but never let it hold her down completely. *Very* active animal, most active animal of the six. Very playful and very hard to suppress in her boisterousness Also seemed to be hungrier than other animals

2. *Housing and Care* The housing and care of these animals differ in no essential respect from those described in the second paper in this series (2) Reference should be made to that paper for details. The animals were isolated in their individual living cages at all times except during experimental observations

3. *Apparatus and Procedure.* The apparatus used in this experiment was practically the same as that used in the previous experiment. The animals, as before, were tamed prior to the beginning of the experiment so that they could be led on a chain from their living cages to the experimental chamber without emotional upset. In this chamber, they were introduced to their partners, and it was in this experimental chamber that *all* social contacts took

place Observations were made from behind a one-way screen. The dimensions of this cage were 36 in x 36 in. x 40 in. It was set on a linoleum flooring which was covered with shavings, one or two inches deep.

In the previous experiment, it had been found that most of the dominance behavior in an experimental period occurred at the beginning of this period In the present experiment, therefore, the length of this period was halved from 20 minutes to 10 minutes. Accordingly 10 bits of food were used in the food test instead of the previous 20. The first set of three interpairings was continued for 30 experimental periods of 10 minutes each, with three additional periods of observation with the animals under starvation conditions After this first set of interpairings, the pairs of animals were tested for only 10 experimental periods, since by this time they had become more accustomed to the experimental routine. The correlations in the first set of three interpairings were somewhat attenuated by the differential fear reactions of the animals to the experimental routine. These differential reactions were apparently independent of dominance. Food was not introduced into the experimental situation until the sixth period. In this way we were able again to test the effect of food or struggle for food on the establishment and maintenance of dominance.

The scoring sheets were slightly different from those used in the previous experiment The following items which had been scored in the previous experiment were not scored in the present one because they had been found impossible to observe accurately, or because they were not connected with dominance; genital inspection, erection, anger, and quiet sitting The new behavior category of "resistance to aggression" was introduced into the new scoring sheet but turned out not to be very useful.

The pairings were as follows, in chronological order:

First set—Blue and Red, Naomi and Kathryn, Whitey and Christy
Second set—Blue and Whitey, Christy and Kathryn, Naomi and Red
Third set—Whitey and Red, Naomi and Christy
Fourth set—Whitey and Naomi, Red and Kathryn
Fifth set—Red and Christy, Whitey and Kathryn

Blue died after the second set of pairings, leaving five animals for interpairings It will be seen that every animal was paired with every other animal of the group, and it is possible to construct a hierarchy of dominance on the basis of these results

After all the interpairings had been completed, the behavior of these same animals in larger groups was studied in the following way. A large outdoor cage, equipped with shelves and an indoor compartment, was used The animals were transferred one by one to this outdoor cage in inverse order of dominance. On the first day, the two least dominant animals were brought in together (C and K) On the next day, the next highest animal in the dominance hierarchy was brought in and allowed to stay there, and so on until all the animals had been put into the outdoor cage They were allowed to stay in this cage all the time. No attempt was made to isolate them in between observation periods. These observations were made at various times during the day as often as the writer's other duties permitted. He always fed them himself, and was particularly concerned with the changes in group behavior wrought by the introduction of food He was also primarily interested in observing all behavior that could not have been predicted from the data already obtained in the interpairings, e.g , different hierarchy of dominance, reversals of dominance, alliance groups, etc

III. RESULTS

The results for the 12 pairings are presented in Tables 2-13 The raw data are given rather than the mere ratios as in the previous experiment (5). The two sets of tables will thus supplement each other to some extent The name of the behavior categories for which scores were taken will be found at the left side of the tables, the number of the experimental period will be found at the top Two sets of scores are given after each behavior category, one for each animal The score for the dominant animal is always given first. For instance, in Table 2 for the Blue-Red pairing, in the fifteenth period, Blue got seven of the 10 pieces of food, Red got three, Blue bullied Red once and Red responded by flight For the first ten behavior categories, the scores represent merely the number of times the behavior in question occurred For grooming and play, the first number of the pair represents the number of times the behavior occurred, the second number represents the total number of seconds taken up with this behavior. In the last category (activity),

TABLE 2

RAW DATA FOR PAIRING OF BLUE AND RED—BLUE DOMINANT

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Feeding	B						7	9	10	9	10	10	10	10	10	7	10
	R						3	1		1						3	
Presentation.	B																
	R	2															1
D. V	B	8	3			1											2
	R																
Attempt	B																
	R																
Bullying.	B											1	1			1	
	R																
Cringing	B																
	R																
Passivity	B																
	R	8	3			1							1				2
Flight	B																
	R											1	1			1	
Resistance	B																
	R																
Fighting:	B																
	R																
Grooming	B			2–50	3–90	1–270			1–5		1–15						
	R	5–200	3–365		1–90	1–15											
Play	B																
	R																
Activity	B	90	15	20	70	55	30	385	405	265	410	385	535	460	360	475	490
	R	120			15	40		385	255	300	480	460	320	370	255	345	335

TABLE 2 (*continued*)
RAW DATA FOR PAIRING OF BLUE AND RED—BLUE DOMINANT

		17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
Feeding	B	10	9	8	9	10	9	10	9	9	10	10	8	10	10	10	8	8
	R		1	2	1		1		1	1			2				2	2
Presentation	B																	
	R								1									
D V	B						3	13	10				2	1		3		
	R							2										
Attempt	B										1							
	R							4	1						1	1		
Bullying	B		1	1	3	5	5	6	6	2	1	1		2		1	1	3
	R																	
Cringing	B																	
	R																	
Passivity·	B							1										
	R		1		3	5	4	14	11			1	2	1		3		2
Flight	B																	
	R		1	1	1		2	4	3	2	1	2				1		1
Resistance:	B																	
	R							1										
Fighting·	B																	
	R																	
Grooming	B	1–40	1–20					1–10					1–10	1–10				
	R																	
Play.	B																	
	R																	
Activity	B	255	180	255	325	255	65	15	15	85	90	70	90	60	115	160	185	445
	R	245	180	245	270	280	215		230	260	155	155	155	145	260	195	70	230

TABLE 4
Raw Data for Pairing of Whitey and Christy—Whitey Dominant

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Feeding	W						7	10		3	3	8	7	8	7	3	4
	C						3		10	7	7	2	3	2	3	7	6
Presentation	W																
	C	1										1				1	
D V	W	1													4	1	
	C				1		1	1									
Attempt	W											4			1		
	C																
Bullying·	W																
	C																
Cringing.	W																
	C	2															
Passivity	W				1		1	1									
	C													1	4	1	
Flight·	W																
	C																
Resistance·	W																
	C											1			1		
Fighting	W											1					
	C																
Grooming	W		1–15														
	C	1–295	4–90	2–75	2–65	3–455	4–270	5–280	7–275	6–305	7–345	6–110	7–325	8–375	4–245	3–170	4–165
Play	W																
	C																
Activity	W	30			15		130	90				15		70	25	60	15
	C	30		15	60	15	170	160	20					30	25	60	45

TABLE 4 (*continued*)
RAW DATA FOR PAIRING OF WHITEY AND CHRISTY—WHITEY DOMINANT

		17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
Feeding	W	5	9	7	4	8	8	8	10	9	8	7	9	10	10	7	10	10
	C	5	1	3	6	2	2	2		1	2	3	1			3		
Presentation	W		1															
	C		1		1	1	3	1			1	5			1	2		
D V	W	2			3	2	2	2	1		2	5	1					
	C				1		1		5	3	2	2	4		2			
Attempt	W		1			1		2	2	3	1	1	1					
	C												1					
Bullying'	W										1							
	C																	
Cringing	W																	
	C																	
Passivity	W				1		1		5	3	2	2	4		2			
	C	2			3	4	2	3	2	1	2	7	1					
Flight	W																	
	C					1				2	1					1		
Resistance.	W																	
	C																	
Fighting	W																	
	C																	
Grooming	W													3–95	4–40	2–40	1–5	1–25
	C	5–290	6–315	6–410	9–330	8–410	8–175	4–120	6–380	7–320	10–425	9–285	6–285	4–145	5–215	4–195	2–100	5–170
Play	W																	
	C																	
Activity	W		55	75	70	15	95	40	105	75		50	120	60	25	55	35	60
	C	5	65	100	70	35	165	10	90	45		50	120	60	25	55	35	80

TABLE 5

RAW DATA FOR PAIRING OF BLUE AND WHITEY—BLUE DOMINANT

		1	2	3	4	5	6	7	8	9	10	11
Feeding	B						10	10	10	10	10	10
	W											
Presentation	B											
	W		1	1								
D. V.:	B	7	4	4	2	3	4	3	7		2	5
	W											
Attempt.	B	7	5		1			1				
	W		1									
Bullying	B	7	2	7	3	9	5	10	12	1	13	12
	W											
Cringing	B											
	W	3	3	2		6	6	8	6	1	6	3
Passivity	B											
	W	4	1	2	3	1	7	2	7		2	5
Flight	B											
	W	10	5	10	3	6	7	11	8	1	9	4
Resistance	B											
	W	1		1		1	3				3	5
Fighting	B	1		2								
	W											
Grooming	B		3–155	2–20	2–20				3–25		1–5	
	W											
Play	B											
	W											
Activity	B	105	250	190	225	235	55	75	90	310	150	120
	W			65	95	80		10		220	20	

TABLE 6

RAW DATA FOR PAIRING OF CHRISTY AND KATHRYN—CHRISTY DOMINANT

		1	2	3	4	5	6	7	8	9	10	11
Feeding	C						7	8	10	10	10	7
	K						3	2				3
Presentation	C	1		1	1							
	K	1		3	1	5	2	1	3	4	1	1
D. V	C		1	1		3	3			1		
	K											
Attempt	C											
	K											
Bullying	C	2				4	4	2	4	6	5	3
	K							1				
Cringing	C											
	K											
Passivity.	C											
	K		1	1		5	3	2	1		3	5
Flight	C											
	K	3					4	2	1	10	5	2
Resistance	C											
	K	2					3					
Fighting	C	2		1			1	1	1			
	K					1						
Grooming	C	1–240	3–145	7–140	6–230	7–145	4–40	5-100	2–20	3–20	2–25	4–95
	K		4–320	2–70	2–15	1–5		1–20			2–15	
Play	C											
	K		4–40	2–10						3–20		1–5
Activity.	C	160	10	30	85	90	95	30	130	45	55	70
	K	220	90	315	135	270	470	345	455	350	325	465

TABLE 7

RAW DATA FOR PAIRING OF RED AND NAOMI—NAOMI DOMINANT

		1	2	3	4	5	6	7	8	9	10	11
Feeding	N						5	10	10	9	10	10
	R						5			1		
Presentation:	N	5	6				1			1		
	R											
D. V.	N	1		2		1		4			6	1
	R	1										
Attempt:	N			3	2	2		1	1	1	1	
	R											
Bullying·	N	2	4	6	1	2		7	3	2	5	1
	R											
Cringing	N											
	R									2	6	
Passivity.	N											
	R		1	5		1		6	1			2
Flight:	N											
	R	3	7	5	3	4		5	2	2	9	2
Resistance.	N											
	R	1		3				1	2		1	
Fighting	N	1		6		3		2	3	1		1
	R											
Grooming	N			1–10		2–15					1–5	
	R											
Play:	N											
	R											
Activity·	N	165	250	210	55	175	65	120	190	380	280	545
	R	150	100	150	90	10	20	80	175	130	180	420

TABLE 8

RAW DATA FOR PAIRING OF WHITEY AND RED—WHITEY DOMINANT

		1	2	3	4	5	6	7	8	9	10
Feeding	W						8	7	8	8	2
	R						2	3	2	2	8
Presentation:	W										
	R	4	2		1	1	1	1			
D V.:	W	9	1	1	9	3		2	1	1	2
	R	3	1								
Attempt	W	1					1	1		1	
	R		3								
Bullying	W				1					1	
	R										
Cringing	W										
	R										
Passivity	W	2	1								
	R	10	1	1	8	2		2	1	1	2
Flight	W										
	R				1					2	
Resistance	W										
	R										
Fighting	W										
	R										
Grooming	W	5	2	1		1			1		
	R	3	2								1–10
Play:	W										
	R										
Activity:	W	135	335	195	360	245	230	420	240	60	165
	R	175	490	345	480	420	215	485	380	325	325

TABLE 9
RAW DATA FOR PAIRING OF NAOMI AND CHRISTY—NAOMI DOMINANT

		1	2	3	4	5	6	7	8	9	10
Feeding:	N						10	10	9	10	10
	C								1		
Presentation:	N	2	1								
	C					1		1			
D V.:	N	1	2	3	2	5	1	2	2	5	
	C										
Attempt.	N			1		3					
	C	1									
Bullying:	N	1	2	6	2	5	5	4	5	13	11
	C										
Cringing	N										
	C			1	3	5	2	3	3	7	2
Passivity	N										
	C	2		4	1	2			2	3	3
Flight	N										
	C		2	5	2	4	6	4	6	8	9
Resistance	N										
	C		1				1				
Fighting.	N		1				2				
	C										
Grooming.	N			1–285	1–280	4–75	1–110	1–420			
	C	4–120	2–20						3–340	1–30	1–15
Play	N										
	C										
Activity	N	225	215	60	175	80	290	40	40	160	225
	C	205	255	60	140	20	260	15	40	120	140

TABLE 10
Raw Data for Pairing of Naomi and Whitey—Alternating Dominance
(Whitey probably dominant)

		1	2	3	4	5	6	7	8	9	10
Feeding	N						7	2	10	8	8
	W						3	8		2	2
Presentation	N	5	5	1	1	3	3		1	2	1
	W										
D V	N										
	W	2						2		1	2
Attempt	N										
	W	1			1			1			1
Bullying	N										
	W						1	1			
Cringing.	N										1
	W					1					
Passivity	N							1		1	2
	W										
Flight.	N						1	2		1	3
	W		1								
Resistance:	N										
	W										
Fighting.	N	1									
	W										
Grooming	N				1–40			3–410	3–235	2–395	3–300
	W				1–10			1–20		2–20	2–25
Play.	N					1–410	1–10				
	W										
Activity·	N	80	440	155	495	45	290	65		25	95
	W	40	70	75	170		60	30	10	25	40

TABLE 11

RAW DATA FOR PAIRING OF RED AND KATHRYN—RED DOMINANT

		1	2	3	4	5	6	7	8	9	10
Feeding:	R						10	10	10	10	10
	K										
Presentation.	R										
	K	6		4	7	1	6	3	4	3	1
D V	R										
	K										
Attempt	R										
	K										
Bullying.	R	10	7	11	7	5	5	6	10	15	6
	K										
Cringing:	R										
	K			1				2		3	5
Passivity	R										
	K			3	2		3	3	7	9	2
Flight.	R										
	K	12	6	7	4	5	6	8	6	6	6
Resistance.	R										
	K		3						1		
Fighting	R										
	K										
Grooming	R										
	K										
Play.	R										
	K										
Activity	R	100	190	185	170	160	120	75	110	65	110
	K	330	520	380	360	455	465	290	165	175	265

TABLE 11

RAW DATA FOR PAIRING OF RED AND KATHRYN—RED DOMINANT

		1	2	3	4	5	6	7	8	9	10
Feeding	R						10	10	10	10	10
	K										
Presentation	R										
	K	6		4	7	1	6	3	4	3	1
D V..	R										
	K										
Attempt.	R										
	K										
Bullying.	R	10	7	11	7	5	5	6	10	15	6
	K										
Cringing.	R										
	K			1				2		3	5
Passivity	R										
	K			3	2		3	3	7	9	2
Flight	R										
	K	12	6	7	4	5	6	8	6	6	6
Resistance	R										
	K		3						1		
Fighting	R										
	K										
Grooming	R										
	K										
Play.	R										
	K										
Activity	R	100	190	185	170	160	120	75	110	65	110
	K	330	520	380	360	455	465	290	165	175	265

TABLE 11
RAW DATA FOR PAIRING OF RED AND KATHRYN—RED DOMINANT

		1	2	3	4	5	6	7	8	9	10
Feeding	R						10	10	10	10	10
	K										
Presentation	R										
	K	6		4	7	1	6	3	4	3	1
D V..	R										
	K										
Attempt.	R										
	K										
Bullying.	R	10	7	11	7	5	5	6	10	15	6
	K										
Cringing.	R										
	K			1				2		3	5
Passivity	R										
	K			3	2		3	3	7	9	2
Flight	R										
	K	12	6	7	4	5	6	8	6	6	6
Resistance	R										
	K		3						1		
Fighting	R										
	K										
Grooming	R										
	K										
Play.	R										
	K										
Activity	R	100	190	185	170	160	120	75	110	65	110
	K	330	520	380	360	455	465	290	165	175	265

TABLE 12

Raw Data for Pairing of Red and Christy—Red Dominant

		1	2	3	4	5	6	7	8	9	10
Feeding:	R						9	8	10	10	9
	C						1	2			1
Presentation	R	1		1		2	2				
	C		1		1		1	2	1		1
D V.	R	13	11	12	11	9	7	4	2	6	7
	C	3		2	1	2	1	1			
Attempt	R	1				2					1
	C		2	1	2		2	1		1	
Bullying.	R	1	2	1	3	3	1	3	1	1	1
	C										
Cringing	R										
	C					3	1				1
Passivity:	R	2		2		1	1	1			
	C	13	12	11	11	7	7	4	3	7	6
Flight	R										
	C	1	1		1	4	1	3		1	2
Resistance.	R	1			1						
	C	2				1					
Fighting	R	1									
	C										
Grooming.	R			1–35	3–55	2–20					
	C	10–210	3–35	11–270	5–260	3–85	2–25	3–180	3–110	2–250	7–440
Play:	R										
	C										
Activity	R	55	325	90	35	145	175	150	200	135	25
	C	25	260	25	25	60	80	75	135	120	

TABLE 13
RAW DATA FOR PAIRING OF WHITEY AND KATHRYN—WHITEY DOMINANT

		1	2	3	4	5	6	7	8	9	10
Feeding	W						10	9	10	10	10
	K							1			
Presentation:	W			1							
	K	5	4	2		1	3	2	2	1	
D V:	W	1	2				2				
	K										
Attempt	W		2								
	K		2	1					1		
Bullying.	W		3	6	5	8	4	3	8	4	3
	K										
Cringing	W										
	K							1	2	1	
Passivity	W										
	K	2	4	4	5	6			2	1	2
Flight:	W										
	K			3	2	3	6	6	7	3	4
Resistance:	W										
	K					1	1			1	
Fighting:	W										
	K										
Grooming.	W	1–5	1–5	1–5	2–25	1–5	1–15	1–15			1–5
	K	2–290	4–285	2–135	1–45	1–95	2–40	1–90	2–195	1–15	1–170
Play	W										
	K										1–10
Activity	W	20	15		105	45	90	50		120	80
	K	130	160	255	395	310	220	275	205	465	315

only length of time in seconds is given. For instance, in this same table, *in the fifth period, Blue groomed Red once for 270 seconds,* and Red groomed once for only 15 seconds. The activity scores are very crude and unreliable. They can be considered significant only when there are large and consistent differences.

Table 14 is a summary of these raw data insofar as they have

TABLE 14
SUMMARY OF DATA IN TABLES TWO—THIRTEEN

	B	N	W	C	B	N	W	N	W	R	R	W
	R	K	C	K	W	R	R	C	N?	K	C	K
Feeding	259	163	199	52	60	54	33	49	15	50	46	49
	21	117	81	8	0	6	17	1	35	0	4	1
Presentation	0	0	1	3	0	13	0	3	0	0	6	1
	4	15	19	22	2	0	10	2	22	35	7	20
D V	46	28	27	9	41	15	29	23	7	0	82	5
	2	0	21	0	0	1	4	0	0	0	10	0
Attempt	1	5	17	0	14	11	4	4	4	0	4	2
	7	0	1	0	1	0	3	1	0	0	9	4
Bullying	41	83	1	30	81	33	2	54	2	82	17	44
	0	0	0	1	0	0	0	0	0	0	0	0
Cringing	0	0	0	0	0	0	0	0	1	0	0	0
	0	0	2	0	44	8	0	26	1	11	5	4
Passivity	1	8	21	0	0	0	3	0	0	0	7	0
	62	32	33	21	34	16	28	17	4	29	81	26
Flight	0	0	0	0	0	0	0	0	1	0	0	0
	23	23	5	27	74	42	3	46	7	66	14	34
Resistance	0	0	0	0	0	0	0	0	0	0	2	0
	1	3	2	5	14	8	0	2	0	4	3	3
Fighting	0	1	1	6	3	17	0	3	0	0	1	0
	0	0	0	1	0	0	0	0	1	0	0	0

V V —1

significance for dominance. Thus the scores for grooming, play, and activity are not included in this table. In this table the name of the dominant animal is always placed above that of the subordinate animal. The same is true for the scores.

It will be seen that in 11 of the 12 pairings, dominance was unmistakable and consistent. In the Whitey-Naomi pairing, dominance changed and was unstable. We shall accordingly omit the data

TABLE 15

TOTALS AND PERCENTAGES FOR ELEVEN DOMINANT AND ELEVEN SUBORDINATE ANIMALS

	Eleven dominant animals		Eleven subordinate animals	
	Totals	Percentage	Totals	Percentage
Food	1014	80	256	20
Presentation	27	17	136	83
D V	305	89	38	11
Attempts	62	70	26	30
Bullying	468	99 9	1	0.1
Cringing	0	0	100	100
Passivity	40	10	379	90
Flight	0	0	357	100
Resistance	2	4	45	96
Initiation of fighting	32	97	1	3

for this pairing from further discussion. With this pairing omitted, Table 15 is a final summing up of the data in the previous table The data for the 11 dominant animals are lumped and compared with the data for the 11 subordinate animals.

A comparison of this table with Table 16 of the second paper in this series (5) will be instructive Percentages for the dominant animals in that group and the same percentages for the dominant animals in the present experiment are given in Table 16

It will be seen that the quality of the behavior syndromes characteristic of the dominant animal and of the subordinate animal remains about the same, even though fairly wide percentage differences for various details of the syndromes are observable in the comparison These differences are really very small if we consider the many

TABLE 16

LUMPED DATA PERCENTAGES FOR ALL DOMINANT ANIMALS COMPARED WITH SIMILAR DATA OF PREVIOUS EXPERIMENT

	Previous experiment Ten dominant animals Percentage	Present experiment Eleven dominant animals Percentage
Food getting	97	80
Presentation	43	27
D-V mounting	98	89
Bullying	99	99 9
Cringing	0	0
Passivity under aggression	1	10
Flight	1	0
Initiation of fighting	85	97

variable factors that are impossible to control, e g., differences in hunger drive, differences in grooming drive, differences in adaptation to the experimental situation, etc. We are inclined to consider the data obtained in the first experiment more reliable than those obtained in the present experiment since only six animals were used in various pairings in the latter Any uncontrolled attenuating variable present in one animal would have a much larger effect on the final group score if this one animal were used in four pairings instead of being used in only one.

It is all the more remarkable that the percentage scores for mounting, bullying, cringing, and flight are so similar in the two experiments These are apparently the best and most reliable indicators of dominance and subordination.

Grooming The results for grooming definitely indicate that, even if grooming were to some extent determined or influenced by dominance status, this connection is so tenuous, or so intermingled with other determining factors which work in other directions, that nothing can as yet be said about it In our previous study we found that the dominant animal groomed more often than he was groomed (62 per cent of all plus scores). In the present experiment the data are almost exactly reversed We find that the subordinate animals gets 66 per cent of all plus scores for grooming.[3] We are compelled in the light of these data to withdraw the tentative suggestion we made in that paper that there might be a correlation of grooming behavior with dominance status Our conclusions as to the extent of altruism in this behavior in the macaque, however, are not affected by these results

Establishment of a Hierarchy Were it not for the reversals of dominance in the Whitey-Naomi pairing, the hierarchy would be perfect In any case this means no more than a possible reversal of two neighboring positions in the hierarchy. Since Whitey was more dominant by mere inspection and also since he scored *more* dominant in the more crucial scores mentioned above, we shall consider him to have been the dominant animal in this pairing at least for the purpose of constructing the hierarchy.

The hierarchy then from most dominant to least dominant would be (1) Blue, (2) Whitey, (3) Naomi, (4) Red, (5) Christy, and

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[3] The calculations are not included here in order to save space They may be easily derived from the tables, however

) Kathryn There were no exceptions to this order Each animal as dominant to every animal below him in the scale in all the parate pairings.

Size and Dominance. A comparison with Table 1 will show that iere is at least a general trend for the largest animal to be the most ominant. If the correlation were perfect, Whitey should have been ore clearly dominant over Naomi than he was Red and Naomi eighed about the same, but Naomi was clearly dominant over Red ienerally these data substantiate the conclusion previously arrived (1), that large difference in size usually insures dominance to ie larger animal but small superiority in size may be outweighed by ocial attitudes of cockiness, confidence, and aggressiveness

The Effect of Starvation on Dominance. The last three experi-iental periods of the first set of interpairings were under conditions f relative starvation. It will be seen that the general effect was ne of heightening and sharpening of dominance. The overlord ı every case behaved in a typically dominant fashion whether or ot he had previously done so. A better way of describing what appened is to say that if there had been any lapses in the dominance ehavior syndrome of the overlord, there were none in these three eriods. Under conditions of starvation the dominance behavior /ndrome emerges clearly and with less lapses and less tolerance)f course it would then be expected that if the overlord had been ehaving in such a fashion under ordinary conditions, starvation 'ould make no difference in his behavior. A starvation technique 'ould then appear to be on theoretical grounds the best way of de-'rmining the true overlord in a pair of animals which had vacillated nd changed In retrospect this would indicate that, in the Whitey-Jaomi pairing, the doubtful status of their dominance rôles could ave been resolved by such a technique The theoretical and prac-cal implications of these scanty data indicate the probable fruitful-ess of a careful and complete research on the question.

Behavior in the Group Full descriptive notes were taken in onghand by the experimenter who sat in front of the cage in full iew. It was his impression that his presence disturbed the animals or a few minutes and then was neglected so long as he made no udden moves When it was necessary to get up to feed them or for ome other reason, the animals were markedly disturbed for a ioment. Since this happened infrequently, it was probably of little importance except during feeding The influence of the writer's presence on feeding behavior and general social adjustment is described in the following notes These notes are not given completely because of lack of space. What is presented is taken verbatim from the notes.

Observations on Group Behavior

Wednesday, August 28th

4 30 PM Fed at 12 M Two least dominant animals (K and C) put in together C dominant to K in previous pairing, no attention to each other except tended to huddle, frightened by new cage, no dominance behavior. K more active, no fear of each other. After about 3 minutes K started to groom C, who jumped, and K cringed while C stared (dominance stare) . K very active as usual; C sits quietly on shelf After little grooming by C, he comes to floor for first time K pulls C's chain with hind feet and leads him along 5 seconds (scored as bullying), no protest by C Both up to shelf; he makes several attempts to mount but no room, and she is too active. Finally he mounts fully with K passive Same again—achieved by C presenting to K. She comes up, he turns quickly and mounts—no entrance, no erection, followed by grooming .. They stay together all the time with K more confident and active in new surroundings She starts to play by pulling his chain and he attacks her vigorously She runs . D.V by C, K passive; *momentary, no reaction, few movements.* . He attacks her suddenly for no reason and she walks away He is becoming more active and confident

5 15 PM Next dominant animal brought in (Red)—dominant to both animals in previous pairings. R frightened, K comes over and presents; then C comes over and presents R does nothing C starts to groom and maneuvers round to mount R snarles and bites C who at once presents and tries no more C bullies and seizes K, who runs. C presents as R approaches C becomes much more pugnacious with respect to K since R has been brought in, much dominance staring and snarling She stays away from him now where before they were together Now C stays with R, allying himself with the stronger one, grooms R for the 70 seconds K climbs up to shelf where other two animals sit. C snarls at her and R does too' a few seconds later they keep on threatening K who flees often C presents to R (full) and grooms again Again K comes close and C and then R threaten her Again C drives K off shelf, C's threats at her are of bluffing type—running starts and stopping short, opening mouth, jumping up and down, jerky up-and-down head movements, no overt attack, however. Little or none of this behavior occurred before R was brought in R joins bullying when C starts Much unprovoked bullying of K by both. . In spite of continuous bullying and threatening, K continues to attempt to join the other pair. She is continually driven off, usually by C

Thursday, August 29th

4 15 P M All 3 on shelf; K alone, C and R huddled, no activity. Fed them bits of bread through wire screen; 1st feeding since 12 yesterday I had to come close, and all were scared, K least so K has always shown less fear of humans, even in previous pairings In spite of the fact that K was closest to me, R got the first piece of food, even took one away from K when she got it However, she tried hard in spite of R's bullying When he got one mouthful, C and K got some food in spite of fact that R seemed to be trying just as hard. Later R drove K up to shelf, other two on floor in front of me, waiting for food . R got 11 bits of food before C got 1; then 10 more for R before C got 1 C ate crumbs on floor during all this time; K still far away, vocalizing

4 45 P M. Next dominant animal brought in (Naomi)—dominant to all three in previous pairings K huddled up to her at once in ventro-ventral embrace and groomed her. Then N attacked her very viciously K almost frantic in her howling During this mix-up, R kept on bullying N with her passive. They fought until he drove N off shelf and she compensated by threatening K. R was bullying C a bit Then N started bullying K at a distance and looking at R. He got down off shelf and mounted her four times. N continued very angry at K—D.V again by R, N passive. After it, N threatened K and made fuss. R mounted N and while R attacked C, N mounted R for long D V. C, who came close, was viciously attacked by R and N kept on mounting him (R) all the time. Finally N and R huddled and N groomed, K in one corner, C in another Thus two most dominant animals of the four have formed an alliance. R mounts N who was passive, and then grooms her. Same again Full presentation of sexual type by N at all times—sloping back, exposed pelvis, tail high, etc; she is in heat—red sexual skin, oedematous swelling of sexual skin and upper legs and base of tail, red nipples, pouchy face, etc

Now R's mounting of N becomes practically continuous, occurs again and again, interspersed with grooming by R C and K all this time cringing in separate corners, C particularly badly frightened . Same has continued for about 15 minutes, R mounting N continuously, interspersing this with grooming C and K scattered and cringing R often threatens others while mounting As I approached to feed the animals, R rushed down from shelf and chased them all violently even before I dropped any food in The while I was handing it in, N mounted R, repeated this four times. While I fed him, he was all alone. N mounted him once in a while, other two scattered, R got 1st 15 pieces, then K got one. Neither C nor N got one, possibly because N taking advantage of situation to mount R, and C completely cowed. When food stopped, R turned around and mounted N twice, and then she groomed him for a long time Dropped food in, now through different spot—*again immediately* R comes for food, later N mounts him and then grooms him

Put whole bread in slices in cage—K hungriest and boldest of all as always This time came to get it from me Others hung back waiting for me to leave before coming for food

Went away for five minutes When I came back, found amazing change K was now viciously chasing C all around cage. He was in mortal terror. She caught him and bit him and tore at him until he went into cataleptic state. Other two animals came down and joined in They were as vicious. The three of them practically ripped his ears apart—all bloody They left, and K kept on doing this alone. Finally she stopped and settled down to bite him. Everytime R or N growled, threatened or even looked at K, she started turning and biting and bullying C C finally lay in exhausted state, ears bloody, eyes half closed, in waxy flexibility Other three kept on eating bread with N and R growling at K occasionally *Without exception* any growl at her set her after C who ate absolutely nothing all this time and stayed on shelf in dazed state for all the time. *Have never seen as vicious bullying as* K's—who, in any case, had never showed any bullying at all during the whole course of the experiment with any single animal. Same state of affairs for 15 minutes. As I left N mounted K twice

This change in dominance apparently caused by K getting food because more bold, hungry and active and less afraid of me She probably then turned on C who was being afaid, but of me, not of her.

Friday, August 30th

5 30 P M I find C very, very badly bitten; scars all over his face, nose, lips, ears, etc, bloody and torn; completely cowed, in spite of fact that in pairing he was completely dominant over K, and that he had at the beginning of this group experiment tried to mount R C is being left alone now; however, K huddles up to him amiably enough C sits (not cringing) vocalizes freely and even moves a bit in a quiet way Other two scattered and prowling around the cage exploring; no attention to each other during this period. K chased by R once in a while and then huddles up to C; seems friendly R most cocky and confident of group; quite certain of himself K most active but watches N and R carefully Long period of sitting about, apparently paying no attention to each other. Great change from yesterday. Must be pretty hungry and thirsty, not fed for 24 hours. Much vocalizing from R. K huddles to C again C shows no fright, although once before did when K ran over instead of walking over—retracted lips and chattered fearfully. Now for period R up on shelf alone, K huddles to N Suddenly R gets up, pulls K down from shelf by her chain. K huddles to C; N and R tend to form group just as K and C tend to form a group All very calm and quiet.

At *6 o'clock* began dropping bits of bread through the mesh Food gotten in following order R 2, N 5, R 1, N 8, R 25 When 8th bit of food was dropped R pokes K, and drives her away When the 10th bit of food was dropped, R again poked K who was persistent. K at once attacked C for first time today, very viciously At 16th bit of food R really got very angry because N had been getting so much food, attacked her viciously, and all animals went away. R sits alone and gets all food thereafter

Dropped whole sliced bread in, as usual I had to come very close to do this, and all the animals but K ran away She sits here alone until I leave Then they get food by coming up behind K and taking it from her As soon as I bring the food C comes to corner, turns his back and cringes Brought potatoes, water and apples. R paid no attention, remained at back of cage, but as soon as I brought apples, he rushed down in spite of me and got one apple. I put in a good deal of food so that C would get some As there was plenty, they let him eat some, when I left all four were drinking and eating quietly except that, when any one approaches C, he runs away

Sunday, August 31st

4 30 P M. Decide to starve animals for 48 hours—get effect on behavior When came back, found that C had been taken out 24 hours ago by care-taker of laboratory in order to save his life. Apparently hunger caused some change of behavior—witness C's plight, also fact that K has scars on face Must have been beaten However no excitement or turmoil now All *three animals apparently very hungry, cry, vocalize continually.* K on floor alone, R and N on shelf together. No behavior with respect to each other N seems to be in heat still, judging from external anatomical signs but not from behavior

4 45 P.M Dropped bits of bread into cage, and strangely no response from any of the animals. Finally held up whole slice of bread N got down and got 12 pieces in row, no attention to bits on floor Then R came, ate bits on floor and ran back, not interfering with N K definitely seemed impelled to come for food but was afraid to. Then dropped bits of food again—gotten by following animals in order: N 1 bit, R 4, N 2, R 15 in row. When the 6th bit of food was dropped, and N got it, R turned on N somewhat, not enough to make her run but just at that moment K dropped the water pan and the sudden noise made N run R got all the food thereafter. At the far end N picked up a bit of food from the floor R turned and chased her away. She ran very rapidly Then R bullied K who showed great fear, cringing, and presented Same thing, three times 14 more bits of food N got all while R bullied K continuously (must there always be a scape-goat in every group? K has taken C's place). Ten more for N while R is still busy bullying K. R mounts K once. Then 15 bits in row for R N sitting by and not moving. When R goes away, then N gets food. R mounts K again R gets 7 bits of food and deliberately goes up to bully K R gets 14 more bits, dropping each one as he takes it without eating it, until he is really sitting in bread, but N never touches any of it K has been far away ever since food was brought, her back turned on the whole procedure She is almost as cowed as C was Five more bits for N until R comes over from bullying K As soon as R leaves for food, N stops trying until he goes away again. Just noticed K's chain caught in mesh—no wonder she could not run away As soon as I release her, she makes a wild dash for the bread right through N who attacks her viciously (K doesn't care) She takes the bit and gorges herself, grunting all the while. Lot of excitement during all this with R mounting N four times as N bullies K. Finally all settled down to eat K growls at animals in neighboring cage, and R bullies, mounting N again. K continues gorging As R approaches, K goes back to him and makes full presentation He half mounts but does not completely, and K goes back to gorging herself Finally so do N and R, suddenly K runs away for no detectable reason I put in a good deal of food and they continue eating, paying no attention to each other

Monday, September 1st

11 o'clock All three on shelf Surplus food lying around on floor R and N together, K alone No fighting or aggression; no social behavior K apparently not overtly afraid of either animal.

11 10 A. M Next dominant animal, W, brought in Other three up on shelf, looking at him, W on floor R comes down, then N and K R mounts W three times times (in spite of fact that W was completely dominant to him in pairing) Then W turns on R and gives him a good beating All 3 animals gang up on W, but he remains confident and aggressive; ganging continuous, K gets awfully aggressive He beats them again and again, but they remain aggressive, especially K who comes down to floor to snarl in W's face while other two growl from shelf. The three animals on shelf with W continually sitting on floor K grooms R and R grooms N, then both groom N for sometime W's presence seems to make a group of the other three animals W has lost none of his confidence

At *11·15,* N comes down deliberately and presents to W—full and prolonged—grooming each other for a while K grooms R up on shelf, N stays close to W and presents for grooming very frequently N gets around slowly into semi-d.v position for moment, then presents a few times, again mounts him in semi-d.v position—no movements Very cautiously K comes down after grooming R for long time and grooms N. All four animals go indoors where I cannot observe them, and a fight ensues K comes out bitten, but then all three gang up on W again They get all excited, but he remains calm They pull him down and really beat him for a while. K awfully beaten, but she seems to take it without any dampening of her aggression. She keeps starting the fights Finally N and K get W in bad position, biting him badly, and he begins to give fright-pain cries and to turn his back. Now N and K bite him viciously while R mounts K. W runs away with K after him (first flight by W) K is still most aggressive Finally W cringes in corner while she bites him, and R in the excitement keeps on mounting N and K K bullies W tirelessly; W bleeding

11 30 Finally W sits on floor panting, and other three sit quietly on shelf Then they come down to floor K starts walking over to W and he cringes and backs up N comes over and starts bullying while R mounts her W runs away Then K and R join N in chasing and bullying, then quiet for sometime, 3 animals on shelf and W perched fearfully in farthest and highest corner of cage. Food dropped in, gotten in following order. R, K, K, R, K, K, R, K, K, R, R, R; R, R, R K most bold about coming for food, R holds back. K least afraid of my presence and closeness However, no great dominance behavior in this situation Then K and N attack W and R joins viciously. W screams with pain K most vicious and persistent W absolutely beaten, no fight in him any more; his sphincters relax, finally he just goes into cataleptic rigidity in a ball in a corner and stays like that even when no one near We may have to take him out to save him R mounts N and K several times. Leave at *11 45*

At noon W had to be taken out to save his life That evening at *7 P.M*, I did the following experiment. W, who has been recuperating all day in his own cage, and K who has remained in the outside cage with a group, are brought together up to the experimental chamber for pairing As in the previous experiment, W dominant, K behaving subordinately from the very first moment that they were put together This in spite of the fact that only that morning W had to be saved from K's aggression

Behavior in trio in cage as before N+R=group, and K is alone

IV DISCUSSION

Comments on Group Observations. It is obvious that the behavior of these animals in groups could not have been predicted from the data obtained in the interpairings The behavior of a group of three animals is something more than the mere addition of their separately taken reactions to each other. In other words the group of three is qualitatively different from a group of two animals, and a group of four is different in the same way from a group of three animals While the data presented in the notes are very far from being final or definitive, they are yet important and suggestive enough to merit careful consideration This is especially so because many separate researches are suggested by various parts of the data

Behavior in the first group (of two animals) did not differ materially from their behavior in their previous experimental pairing. The introduction of a third animal (who had dominated them separately) introduced new behavior that seemed to be a function of the size of the group Several general statements may be made as suggested descriptions in general terms of this new behavior. It may be that these overlap each other. They are to be considered as provocative rather than final, since the animals involved are too few for final statements (1) Punishment is handed down When the overlord asserts dominance over his immediate inferior in any way, this latter animal is impelled to assert dominance over *his* inferior by bullying, mounting, etc. (2) The middle animal (C) is made more pugnacious generally with respect to the subordinate animal (K) by the introduction of an overlord (R), even though he (C) was not very pugnacious when alone with K (3) The middle animal seems to tend to ally himself with the overlord, and seems to prefer his company to that of his inferior. They tend to form a contact group and act to some extent as a unit. (4) The middle animal, rather than the overlord, tends to initiate the bullying of and fighting with the subordinate animal, even though the overlord may join in. (5) If one animal attacks another, the outsider will join with the attacker rather than with the attacked animal (6) All these considerations seem to justify calling the subordinate animal the "scapegoat animal."

The anomalous middle position thus takes on a certain character of its own. While we should not anthropomorphize about the motivation of his behavior, we can at least point out that the net result of all these activities is (1) to protect the middle animal from the aggression of the overlord, and (2) to allow him to keep the highest possible dominance status.

The introduction of the next more dominant animal brought about behavior that is difficult to interpret, since she was in heat, and consequently the dominance drive assumed in her a less important rôle than might otherwise have been the case. Her presence, however, brought to light new behavior that is worthy of tentative generalization. An animal behaving in a concentrated fashion with respect to animal X seems to become an easier mark for the dominance display of animal Y Several examples of this behavior are recorded in the observations, e g , N bullying K was simultaneously bullied by R

The new types of behavior observed in the three groups are also observed with some modifications in the four group, e.g., when R dominates N, she "hands it down" to K; two most dominant animals form a contact group, all the animals are more pugnacious than they were before.

K's behavior generally was very different from her behavior in the interpairings. In the records for these interpairings, many notes were made of her strong dominance drive. She never had a real opportunity to express it effectively until she became part of a larger group Here she was aided by the apparent tendency noted above of animals on the sideline to come to the aid of an attacker rather than to the aid of the attacked animal. Obviously this gives a weak but pugnacious animal far more power than she could possibly wield in a group of two animals, and would indicate that absolute strength of dominance is more readily seen in a larger than in a smaller group As soon as K made the first attack on C, the other two animals came to her aid and not to the aid of C Once the break was made, and C became subordinate to the group of three animals, he also became subordinate to any *one* of the three. K thereafter adhered admirably to the "principle" of handing down punishment It is interesting to note that, because K continued to be rejected by R and N, she formed a contact group with C and huddled with him amicably at all times except when she was handing down punishment

When C was taken out to save his life, the behavior of the resultant three group slipped back to the behavior of the previous three group

When W was brought into the group, he seemed to suffer under at least one disadvantage, in spite of the fact that he had dominated all of the animals in the group taken separately They now seemed to consider themselves an "in-group" and him an outsider His mere presence at once caused them to coalesce into something of a unit Also they were adapted to the experimental situation and he was not, which gave them another advantage K again led the attack (in the attempt to become what we have called the "middle animal"?). Again R and N came to the aid of K, who attacked W, rather than to the aid of W, who was attacked W was whipped and eventually had to be removed to save his life This left a three group, which acted generally as already described.

It should be noted in C and in W that, when they lost dominance, they lost it suddenly and completely, seeming, in a moment, to give up dominance and accept subordination

About five hours after Whitey had been removed from the group cage, advantage was taken of the opportunity to determine the possibility of a continuing trauma in this animal as the result of his very harrowing group experience. Also the experimenter was very curious *about the question as to whether the dominance status in a pairing* was the result of direct reaction to the elements inherent in the situation, or whether it was more largely the result of previous experience and social conditioning Is an animal who has been subordinate in a previous pairing more likely to be subordinate in a new pairing?

Whitey and Kathryn were again paired in the experimental chamber in exactly the same way that they had been paired prior to the group experiment. It will be remembered that Whitey had been dominant over Kathryn in these pairings (see Table 13), and also that Kathryn was the leader of the group attack on Whitey which finally broke his spirit She bullied him persistently and almost killed him single-handed.

In this pairing which lasted for ten minutes, Whitey was dominant, but not because he asserted or took dominance. He was dominant because of Kathryn's complete concession of this status to him At the very first moment that they were put together, Whitey got into the corner and cringed for ten seconds while Kathryn ran about actively. Then they both ran about for 35 seconds Then K spontaneously came over to W and presented to him of her own accord for fifteen seconds. He responded by genital inspection and then began grooming her. The rest of the ten minutes were spent in sitting about quietly and grooming by W W got seven of the ten bits of food with practically no opposition from K. When K got the food bits, it was because of lack of opposition by W.

The dominance was obviously unmarked and given rather than taken The indication would be then that Whitey was somewhat affected by his previous group experience, but also that Kathryn was again responding to present factors in the situation, e.g., Whitey's superior size. Her previous attitude of dominance in the group situation did not hang over into the present situation, although it was obvious that if she had made any attempt at all to achieve dominance status, Whitey would have been quite ready to accede.

This result would indicate that the technique we used is worthy of further investigation and use.

The Establishment of a Hierarchy Little comment need be made on the clear-cut data we have presented, except that perhaps they should be held suspect just because they are so unexpectedly neat. They indicate that our group was not nearly as evenly matched as we had supposed The differences in weight should have been less than they actually were, since of course we now know that it is very easy to insure in advance a perfect hierarchy by selecting as subjects animals that differ substantially in their body weights. Our animals ranged from 5 lbs, 4 oz. to 8 lbs., 15 oz, or from 2352 grams to 4004 grams. Murchison's six roosters ranged from 3420 grams to 4000 grams (9). Our data are, then, not strictly comparable. Had our animals been as closely matched for weight as Murchison's, we might have got the same circularities of dominance status that he obtained

Attenuating Factors in the Intercorrelations of Dominance Behaviors. We have already pointed out in previous papers (2, 5) that our putative dominance attitude is not the only determiner of specific aspects of the dominance syndrome. Feeding behavior is of course also influenced by strength of hunger drive, by differential appetite for the particular food being used as a test goal object, by differences in speed of reactivity, etc Sexual behavior is also partially determined by stage of the female's sexual cycle, by general differences in strength of sex drive, and by previous experience In the present experiment, several more such factors came to light and may now be listed (1) Fear of the experimenter was a variable quantity from animal to animal, some being much tamer and bolder than others. Kathryn, who was not at all bothered by the presence of the experimenter, won thereby an advantage over the others, particularly in the group experiment (2) Differences in absolute strength of dominance proved to be very important It is possible to rate (roughly) any animal on an absolute scale of dominance. One animal may obviously have a very strong drive to dominance that will manifest itself in any social situation whatsoever, even when he is in a subordinate position due to inferior weight and size. Other animals may be *given* dominance status because they are so much larger than their partners. The general distinction between dominance relative to one other individual and relative to the total of other individuals is important also in avoiding confusion in other contexts (3) The factor of previous dominance or subordination experience does apparently have some effect on present behavior (4) Starvation may effect differentially the dominance-subordination behavior of a pair of animals Our exploratory experiment indicates that the dominant animal's behavior is sharpened and heightened, which in turn inhibits all the more strongly whatever dominance behavior the subordinate animal may have shown prior to starvation. (5) Priority on the spot seems also to have been an influential variable in our group experiment The animals already in the cage have an advantage over newly introduced animals in the struggle for dominance, both because of alliances already formed and because of better adaptation to the strange situation (6) Difference in drive to groom or to be groomed may be influential in partially determining the particular form that dominance behavior will take.

These are, of course, no more than a few of the factors that must inevitably tend to attenuate any correlation between various parts of the dominance behavior syndrome They are sufficient, however, to indicate the complexity of such a task and also to induce a proper respect for the very high correlations actually obtained *in spite of* all these attenuating influences.

V. Summary and Conclusions

In a group of six rhesus macaques, every animal was paired with every animal by the technique described in a previous paper. The behavior syndromes characteristic of dominant and subordinate animals determined in a previous experiment were generally confirmed except for grooming behavior, which was judged not to be correlated with dominance status because of the discrepancy of data in the two experiments. No adequate data on play behavior were obtained and no conclusions were drawn therefore. Mounting and bullying proved to be the most reliable measures of dominance, and cringing and flight were found to be the most reliable measures of subordination

The hierarchy of dominance constructed from the results of the separate pairings was found to be practically perfect in the sense that it showed no circularity of dominance relationships such as had been found in birds This surprising result was adjudged to be probably a consequence of too great differences in weight of the animals in our group.

An exploratory experiment on the effect of starvation seemed to indicate that the dominance of the overlord animal was heightened and sharpened by this treatment.

These animals, after the pairings were completed, were formed into larger groups whose conditions are described It was found that new behavior emerged in these groups that was unpredictable from the data on pairings, since certain behavior is definitely a function of the size of the group. A group of three animals is a different *kind* of a group (in a qualitative sense) from a group of two animals. Animals that had been dominant in the pairings were, in the group, beset by alliances of their subordinates and beaten severely. The animal that had been at the bottom of the dominance hierarchy in the pairings turned out to be the most vicious and aggressive of the animals in the groups of four animals This same animal, when paired separately soon after with one animal that she had almost killed while in the group, turned out to be as subordinate to him as she had been in the original pairing

Various attenuating factors are discussed

Generally the various techniques used in this experiment are considered to have brought to light suggestive rather than conclusive results Many problems and questions have been brought to light that seem to be worth further investigation.

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PERFORMANCE TESTS AS AIDS IN THE DIAGNOSIS OF MALADJUSTMENT*

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The clinical psychologist is in an extremely precarious intellectual position. In his daily occupation he utilizes rather freely certain concepts as regards the nature of the abilities of man and the principles underlying human behavior. He also employs standardized techniques for the measurement of these abilities and for their qualitative analysis. He does that because he has found that in practice, at least, some of the clinical concepts and techniques are helpful in interpreting the behavior and diagnosing the conduct of maladjusted individuals However, upon turning to current literature dealing theoretically and experimentally with the same concepts and techniques, he is often reminded of the fact that they are far from adequate In fact, he cannot help but admit with Spearman, that even "the very concept of intelligence is unsatisfactory" (8, p. 12) Recent studies on the validity and reliability of common clinical techniques are even more disturbing to the clinician It is difficult for him to reconcile the critical analysis and experimental results of others with his own empirical findings as regards the validity or usefulness of these basic concepts and techniques in clinical psychology.

The clinical psychologist often wonders what contribution he could make toward the solution of major current psychological controversies. Indeed, it seems plausible to expect the clinician with his wealth of experience with pathological manifestations of behavior to make substantial contributions in such controversies as the one between the unit-factor and the two-factor theories of intelligence The clinician, however, experiences great difficulty in bringing harmony between the theoretical discussions of such problems as the one on the true nature of intelligence and the manifestations of

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"intelligence," with which he is well acquainted This difficulty is perhaps a result of the early influence of Terman, and his view that to demand "that one who would measure intelligence should first present a complete definition of it, is quite unreasonable" (9, p 44). Stern's analogy of the measurement of intelligence with the measurement of electric currents as well as Spearman's analysis of the fallacy of this analogy (8, p 16) are too well-known to be quoted here

Even if the clinician accepts Spearman's two-factor theory, as a great many tend to do, he must admit that there is no instrument available as yet for the measurement of isolated *S*'s. The practical student of human behavior can hardly conceive of psychological elementary functions or special abilities as independent entities One, therefore, takes a sheer guess when one analyzes an individual's performance on a standardized test in terms of psychological elements or *S*'s. Such an analysis takes one out of the inductive and experimental field and into the deductive and speculative field The clinician must, therefore, view an individual's score on a test, however simple, as the function of his total personality. One's characteristic performance on a given test in a given situation is a sample of one's characteristic way of making adjustments under similar circumstances From the standpoint of the clinician, a valid psychological test is, therefore, one that was found empirically to be a useful instrument for securing an adequate sample of an individual's behavior under standardized conditions.

It has been this view in clinical psychology that has caused certain clinicians to claim that adequate mental tests measure not only intelligence, but also give important indices of individuals' abilities to adjust. It has been claimed by Mateer (6), and others that the unstable child, for instance, rates much lower on a performance scale than on a verbal scale. "For diagnostic purposes, when mental age on performance tests and on Binet tests differ as much as four years, investigations in regard to the emotional stability of the child may be desirable" (7, p. 302) "Throughout, the effort to respond according to the test demands causes, because of his greater predilection for other types of reactions, and consequent greater necessity for constant self-judgment and inhibition of many traits, greater fatigue than is experienced by individuals more like the common groups"

(6, p. 150) Cornell and Coxe (3, p. 55) suggested that a study be made of the relationship of ability to perform on their scale to stability, impulsiveness, and other traits. The question often arises: How reliable are the empirical evidences concerning the performance level of the unstable? Is a difference of four or more years between the Binet scale and the performance scale test ages, for instance, indicative of instability?

THE PROBLEM

The present study[1] consists of a comparison of the performance of adjusted and maladjusted mentally deficient boys on the Witmer Formboard, the Witmer Cylinder, the Cornell-Coxe Performance Ability Scale, and the Kent-Shakow Graded Formboard Series. The specific questions to be answered in this study are (1) Do the Witmer Formboard, the Witmer Cylinder, the Cornell Coxe Performance test ages, and the Kent-Shakow Performance score differentiate the adjusted from the maladjusted mentally deficient boys? (2) Does the difference between the Binet and each of the three performance test ages differentiate between the adjusted and the maladjusted defective? and (3) What is the relationship between the various psychometrics used in this study?

The terms adjusted and maladjusted are here used instead of other such terms as stable and unstable. These terms are used because the writer feels that instability in mentally deficients expresses itself primarily in social maladjustment The adjusted boys studied were found to be continuously very well adjusted, and the maladjusted boys were continuously maladjusted under the same disciplinary and administrative regulations. While it is hard to get two clinicians to agree on a diagnosis of psychopathy or instability, it is comparatively easy for different clinicians to agree on a classification of an individual as either adjusted or maladjusted in view of his total past history and present condition

The present study is one of a series of investigations (1, 2) on the value of various psychometrics in the diagnosis of maladjustment or instability in mental deficients

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[1] This study was made at the State Colony, New Lisbon, N J

METHOD AND PROCEDURE

Constitution of the Two Groups The two groups were highly equated in the following items:

1 Nationality and race Each group consisted of 49 native white and one colored.
2 Sex All subjects in both groups were male
3. Chronological age (First row in Table 1.)
4. Binet test age. (Fourth row in Table 1.)
5. Number of months in the colony prior to the study (Second row in Table 1.)
6. General physical health as rated by the resident physician.

The only outstanding difference between the Adjusted and the Maladjusted was in the matter of continuous social adjustment To study this difference between the two groups, the Vineland Adjustment Score Card (10, 11) was used (Third row in Table 1). The difference between the two groups in scores on the Adjustment Score Card was found conclusively reliable

The institution maintains a detention cottage for the boys who fail to adjust in the ordinary institutional environment. A study of the number of days in the detention cottage, the number of commitments, recommitments, etc, of the boys in the two groups has shown clearly the significant difference between the two groups in continuous social adjustment for at least the past two and one-half years Additional information concerning the two groups may be found elsewhere (1, 2)

RESULTS

A study of Table 1 indicates that the two groups were highly equated in chronological age, number of months in institution prior to the study, and in Stanford Binet test age. The difference between the two groups in scores on the Vineland Adjustment Score Card was conclusively reliable. None of the performance test ages or scores differentiated conclusively between the two groups. A further analysis of the differences between the Adjusted and the Maladjusted in these performance test ages and scores and their significance for diagnostic purposes follow

The Witmer Formboard. The directions given by Young (12) for administering and scoring this test were used in the present study.

TABLE 1

STATISTICAL VALUES OF THE VARIABLES STUDIED

Row	Variables	Range		Mean ± P.E$_M$		S D		D ± P.E$_D$	Critical ratio
		A†	M‡	A	M	A	M		
1	Chronological age*	159—352	157—395	235 38 ± 4 21	235 68 ± 5 06	44 18	53 05	.30 ± 6 59	046
2	Months in institution	9—182	7—190	44 00 ± 3 17	43 96 ± 3 48	33 26	36 48	04 ± 4 71	009
3	Vineland adjustment score	73—138	27—96	107 04 ± 1 60	59 30 ± 1 99	16 75	20 85	47 74 ± 2 55	18 700
4	Stanford-Binet test age	78—182	72—187	107.94 ± 1 93	107 50 ± 2 19	20 22	22 92	.44 ± 2 92	151
5	*Witmer Formboard test age*	79—192	36—192	145 80 ± 3 56	136 70 ± 3 81	37 33	39 93	9 10 ± 5 21	1 750
6	Witmer Cylinder test age	60—192	60—192	127 38 ± 3 99	126 86 ± 4 41	41 80	46 36	.52 ± 5 95	090
7	Cornell-Coxe test age	81—200	59—200	129 58 ± 3 01	121 94 ± 2 88	33 11	31 67	7 64 ± 4 17	1 850
8	Kent-Shakow Formboard 2S score	16—27	0—27	23 82 ± 21	22 48 ± 50	2 15	5 27	1 34 ± 54	2 480
9	Kent-Shakow Formboard 2D score	0—30	0—30	23 86 ± .57	21 88 ± 81	6 02	8 50	1 94 ± 99	1 96
10	Kent-Shakow Formboard 3S score	0—31	0—33	20 82 ± 86	19.08 ± 89	9 02	9 35	1 74 ± 1 24	1 40
11	Kent-Shakow Formboard 3D score	0—41	0—43	16 96 ± 24	16 46 ± 1 31	12.97	13 71	50 ± 1 80	28

† Adjusted

‡ Maladjusted

* *All ages are given in months*

It appears in Table 1 that both the Adjusted and the Maladjusted scored higher on the Witmer Formboard than on the Binet scale. The differences of the mean test ages on the Witmer Formboard and on the Binet for the Adjusted and the Maladjusted were 37.86±4.05 and 29.20±4.39 respectively, and their critical ratios were 9.35 and 6.65 respectively. This is in agreement with similar findings concerning the performance ability of the feebleminded in comparison with their Binet general mental level.

An analysis was made of the differences between each individual's Binet test age and his Witmer Formboard test age. In Table 2 the distribution of these differences for the two groups is given. It appears from this table that the difference between the Adjusted and the Maladjusted in their tendencies to score higher on the Witmer Formboard than on the Binet scale is unreliable. The proportion of those who scored higher to those who scored lower on the Witmer Formboard than on the Binet scale is nine to two for the Adjusted and seven to two for the Maladjusted. The median increases from the Binet to the Witmer Formboard test ages are four years two months for the Adjusted and three years two months for the Maladjusted. The median decrease from the Binet to the Witmer Formboard test ages for both groups is seven months. Forty-four per cent of the Adjusted and 32 per cent of the Maladjusted scored four or more years higher on the Witmer Formboard than on the Binet scale. The percentage difference between the two groups being 12±6.50, it follows then that this difference between the two groups is statistically unreliable. Further analysis of the data indicates that the Witmer Formboard test age and the difference between this and the Binet test ages do not differentiate the Maladjusted from the Adjusted.

The Witmer Cylinder. The directions used for administering and scoring of this test were those given in Healy and Bronner's Manual (4, pp. 115-116). In case of complete failure a test age of five years was assigned. Ten per cent of the adjusted and 20 per cent of the Maladjusted were thus assigned a test age of five years. On the other hand, 8 per cent of the Adjusted and 16 per cent of the Maladjusted achieved a maximum test age of 16 years on this test. From Table 1 it appears that there is conclusive evidence of a reliable difference between the mean test ages on the Binet scale and

TABLE 2

DISTRIBUTION OF THE DIFFERENCES BETWEEN THE WITMER FORMBOARD AND THE BINET TEST AGES IN YEARS AND MONTHS OF THE ADJUSTED AND MALADJUSTED

Witmer Formboard test age minus Binet test age	Adjusted	Maladjusted	Adjusted and maladjusted
+9·0	1	0	1
+8 0	2	0	2
+7 6	0	1	1
+7 0	1	4	5
+6 6	1	4	5
+6 0	1	0	1
+5 6	7	1	8
+5 0	3	2	5
+4 6	2	2	4
+4 0	4	2	6
+3 6	2	2	4
+3.0	3	2	5
+2 6	1	1	2
+2 0	1	4	5
+1·6	3	4	7
+1 0	5	4	9
+ 6	2	1	3
Less than + 6	2	4	6
0	0	1	1
Less than — 6	1	4	5
— ·6	5	2	7
—1 0	1	1	2
—1 6	1	1	2
—2 0	0	1	1
—3 6	0	2	2
—5.0	1	0	1
N	50	50	100
Percentage Witmer Formboard T.A. higher than Binet T A	82	76	79
Percentage Witmer Formboard T A. lower than Binet T A.	18	22	20
Median Witmer Formboard T A. higher than Binet T A	4 2	3·2	3 10
Q Witmer Formboard T A higher than Binet T.A.	1 11	2.0	2 0
Median Witmer Formboard T A lower than Binet T A	0 7	0·7	0 7
Q Witmer Formboard T A lower than Binet T A	0.8	1 2	0·8
Percentage between ±1 0 deviation	20	24	22
Percentage between ±2 0 deviation	40	44	42
Percentage over +4 0 deviation	44	32	38

the Witmer Cylinder of both groups. The differences between the mean test ages on the Witmer Cylinder and on the Binet for the Adjusted and the Maladjusted are 19.44±4.43 and 19.36±4.92 respectively, and their critical ratios are 4.39 and 3.94 respectively. As in the case of the Witmer Formboard, both the Adjusted and the Maladjusted scored higher on the Witmer Cylinder than on the Binet test. However, from the standpoint of differentiating the Maladjusted, both of these performance test ages appear to be of no value.

In Table 3 further analysis of the distribution of the differences between the Binet and the Witmer Cylinder test ages of the two groups is given. The tendency for both groups to score higher on the Cylinder than on the Binet is not as pronounced as in the case of the Witmer Formboard. Sixty-two per cent of each group scored higher on the Cylinder than on the Binet. The mean plus difference between the Cylinder and the Binet test ages for the Adjusted and the Maladjusted are three years ten months, and four years four months respectively. The mean minus differences between the Cylinder and the Binet test ages for the two groups are one year six months, and one year eleven months respectively: 28 per cent of the Adjusted and 32 per cent of the Maladjusted scored four years and above higher on the Witmer Cylinder than on the Binet scale. This difference between the two groups is, therefore, insignificant and statistically unreliable.

The Cornell-Coxe Performance Ability Scale. Cornell and Coxe (3) studied some of the possible interpretations or reasons for differences between the results of the Binet tests and performance scale tests. The following six tests of the Cornell-Coxe performance scale were used: Manikin-Profile, Kohs Block Designs, Picture Arrangement; Digit Symbol Substitution; Memory for Designs; and Cube Construction. The directions for administering and scoring the tests used were those given by Cornell and Coxe.

From Table 1 it follows that the differences between the Cornell-Coxe and the Binet test ages for the Adjusted and the Maladjusted are 21.64±3.58 and 14.44±3.62 respectively, and their critical ratios are 6.04 and 4.57 respectively. In other words, there is conclusive evidence that both the Adjusted and the Maladjusted mentally deficients will always score higher on the Cornell-Coxe performance scale than on the Binet scale. This finding agrees with

TABLE 3

DISTRIBUTION OF DIFFERENCES BETWEEN THE WITMER CYLINDER AND THE BINET TEST AGES IN YEARS AND MONTHS OF THE ADJUSTED AND MALADJUSTED

Witmer Cylinder test age minus Binet test age	Adjusted	Maladjusted	Adjusted and maladjusted
+8·6	0	1	1
+8·0	1	1	2
+7·6	2	0	2
+7·0	3	4	7
+6·6	1	3	4
+6·0	1	0	1
+5·6	1	3	4
+5·0	2	1	3
+4·6	3	2	5
+4·0	0	1	1
+3·6	3	1	4
+3·0	1	1	2
+2·6	0	1	1
+2·0	3	2	5
+1·6	3	1	4
+1·0	3	3	6
+ ·6	1	2	3
Less than + ·6	3	4	7
Less than — ·6	0	1	1
— ·6	4	2	6
—1·0	5	2	7
—1·6	2	5	7
—2·0	3	1	4
—2·6	1	2	3
—3·0	0	2	2
—3·6	1	2	3
—4·0	1	2	3
—4·6	2	0	2
N	50	50	100
Percentage Witmer Cylinder T.A. higher than Binet T.A.	62	62	62
Percentage Witmer Cylinder T.A. lower than Binet T.A.	38	38	38
Median Witmer Cylinder T.A. higher than Binet T.A.	3·10	4·4	3·10
Q Witmer Cylinder T.A. higher than Binet T.A.	2·3	2·8	2·7
Median Witmer Cylinder T.A. lower than Binet T.A.	0·11	1·0	1·0
Q Witmer Cylinder T.A. lower than Binet T.A.	1·6	1·11	1·9
Percentage between ±1·0 deviation	16	18	17
Percentage between ±2·0 deviation	42	40	41
Percentage over +4·0 deviation	28	32	30

the previous ones as regards the performance level of the two groups on the Witmer Formboard and the Cylinder. In the case of the Witmer Formboard, however, the mean test ages of the two groups were almost as high as the average for the normal unselected population. While in the case of the Cornell-Coxe performance scale, the mean test ages for both groups are nearer to their own Binet general mental level than to that of an unselected group. This would indicate that the mentally deficients as a group may score average on a simple performance type of test However, when they are tested on a more complex type of performance scale, they function, as a rule, on a level nearer to their own Binet general mental level than to the average for an unselected group

In Table 4 a further analysis of the differences between the Cornell-Coxe performance and the Binet test ages of the two groups is given It appears very clearly from this table, as was already pointed out, that both the Adjusted and Maladjusted mentally deficients tend to score not very much higher on the Cornell-Coxe performance scale than on the Binet. Eighty-two per cent of the Adjusted and 76 per cent of the Maladjusted scored higher on the Cornell-Coxe scale than on the Binet. The median increases from the Binet to the Cornell-Coxe scale for the Adjusted and Maladjusted were one year nine months, and one year six months respectively. Eighteen per cent of the Adjusted and six per cent of the Maladjusted scored four or more years higher on the Cornell-Coxe scale than on the Binet. The percentage difference being 12±4.31, it follows that there is a marked probability that this difference between the two groups is a true one; that is, there seems to be experimental evidence in this study that the Maladjusted will have more individuals than the Adjusted scoring four or more years higher on the Cornell-Coxe scale than on the Binet. This finding loses a part of its diagnostic value in view of the fact that 60 per cent of the Adjusted and 62 per cent of the Maladjusted scored between plus or minus two years difference between the Cornell-Coxe and Binet test ages.

The Kent-Shakow Graded Formboard Series. The clinical model of the Kent-Shakow Formboard (5) was used in this study A preliminary tryout of the test has shown that by far the great majority of the mentally deficient subjects, functioning on the high-grade moron level, cannot pass any of the tests above the 3D form

TABLE 4

DISTRIBUTION OF THE DIFFERENCES BETWEEN THE CORNELL-COXE PERFORMANCE AND THE BINET TEST AGES IN YEARS AND MONTHS OF THE ADJUSTED AND MALADJUSTED

Cornell-Coxe Performance test age minus Binet test age	Adjusted	Maladjusted	Adjusted and maladjusted
+7 6	1	1	2
+6 6	1	0	1
+5 6	2	1	3
+5 0	2	0	2
+4 6	2	1	3
+4 0	1	0	1
+3 6	3	3	6
+3 0	2	2	4
+2 6	3	7	10
+2 0	2	0	2
+1 6	5	5	10
+1 0	8	6	14
+ ·6	6	7	13
less than + 6	3	5	8
0	0	2	2
less than — 6	3	2	5
— 6	0	2	2
—1 0	4	2	6
—1·6	1	0	1
—2 0	0	1	1
—2 6	0	2	2
—3 0	0	1	1
—5·0	1	0	1
N	50	50	100
Percentage Cornell-Coxe Performance T A higher than Binet T A	82	76	79
Percentage Cornell-Coxe Performance T.A. lower than Binet T A	18	20	19
Percentage Cornell-Coxe Performance T A equal to Binet T A	0	4	2
Median Cornell-Coxe Performance T A higher than Binet T A	1·9	1 6	1·7
Q Cornell-Coxe Performance T A. higher than Binet T A	1 4	1·0	1·1
Median Cornell-Coxe Performance T A lower than Binet T A	1·1	1 2	1·1
Q Cornell-Coxe Performance T.A lower than Binet T A	0 7	1 0	1·0
Percentage between ±1·0 deviation	24	36	30
Percentage between ±2 0 deviation	60	62	61
Percentage over +4.0 deviation	18	6	12

The following forms were therefore used: 2S, 2D, 3S, and 3D. This formboard, from a general clinical viewpoint, is most valuable for the study of the individual's ways of meeting new problems and making necessary adjustments to novel situations. This test is particularly valuable for the clinician in observing the individual who fails to profit by experience, the one who ordinarily uses a hit or miss method in meeting novel situations, or the individual who carefully plans his performance, who profits by previous experiences, and who is able to generalize his experience and thereby bring about considerable transfer. It is doubtful whether such clinical observations on the values of this formboard series can be expressed in terms of end-scores. However, it is significant to note that of a number of formboards used, the Kent-Shakow Formboard 2S has shown definite indications of possessing differentiating qualities with regard to social adjustment.

It appears from Table 1 that, with each successive form of this series, the more difficult the form becomes, the less reliable the difference between the two groups The critical ratios become smaller and the sigmas become more alike; the amount of overlapping between the distributions of the two groups also increases with each successive form. There are 95 chances in 100 that the Adjusted will always score higher on the Kent-Shakow Form 2S. In the case of the Form 3D, the chances are only 58 in 100 that the Adjusted will always score higher than the Maladjusted. From the standpoint of differentiating the maladjusted, then, Form 2S is superior to the succeeding forms. The more difficult they become, the less do they differentiate with regard to adjustment.

Intercorrelations The intercorrelations between the various psychometrics used in this study are given in Table 5 for the Adjusted, the Maladjusted, and for both groups combined. All of the intercorrelations are positive, and range between 120–.841 for the Adjusted, 186–.765 for the Maladjusted, and 243–.687 for both groups combined. Twenty-eight intercorrelations are given for each group in Table 5. In 12 of these, the coefficients of r are higher, and in 16 they are lower for the Adjusted than for the Maladjusted There appears to be a higher consistency between the Binet and the various performance test ages of the Maladjusted than the Adjusted. This difference between the two groups is not sufficiently high for predictive purposes. The intercorrelations between

TABLE 5

INTERCORRELATIONS

	Variables	Group	2	3	4	5	6	7	8
	Stanford	A	.296	193	537	482	307	444	.533
1	Binet	M	427	283	602	336	433	.433	474
	test age	A+M	366	243	566	350	380	436	500
	Witmer	A		628	566	604	385	772	538
2	Formboard	M		615	684	555	560	547	537
	test age	A+M		617	630	540	494	657	535
	Witmer	A			547	534	412	120	239
3	Cylinder	M			.587	186	212	314	572
	test age	A+M			563	490	.400	509	523
4	Cornell-Coxe	A				687	464	668	702
	Performance	M				.496	573	.653	.765
		A+M				.514	524	663	730
	Kent-Shakow	A					606	841	729
5	Formboard 2S	M					623	661	450
	score	A+M					612	665	487
	Kent-Shakow	A						701	547
6	Formboard 2D	M						599	500
	score	A+M						637	510
	Kent-Shakow	A							.746
7.	Formboard 3S	M							634
	score	A+M							687
	Kent-Shakow					A	50		
8	Formboard 3D				Number	M	50		
	score					A+M	100		

the various performance tests used are not sufficiently high for prediction *In the case of the Adjusted, there was found to be a closer* relationship between the levels of performance on the various forms of the Kent-Shakow Formboard series than in the case of the Maladjusted One might therefore conclude that the Adjusted are more consistent than the Maladjusted in their performance on the Kent-Shakow Formboard series

SUMMARY AND CONCLUSIONS

A comparative study was made of the performance of 50 very well-adjusted and 50 seriously maladjusted mentally deficient boys in an institution, on the Witmer Formboard, Witmer Cylinder, Cornell-Coxe Performance Ability scale, and the Kent-Shakow Graded Formboard series. The specific questions to be answered in this study were. (1) Do the performance test ages and scores differentiate the Adjusted from the Maladjusted? (2) Does the difference between the Binet and the performance test ages differentiate between the adjusted and the maladjusted mentally deficient boy? and (3) What is the relationship between the psychometrics in this study? The two groups were highly equated in nationality, race, sex, chronological age, Binet test age, number of months in the institution, and in general physical health The only outstanding *difference between the two groups was in the matter of continuous* social adjustment. This difference was shown to be conclusively reliable by comparing the Vineland Adjustment Score Card scores of the two groups, and their adjustment and behavior records in the institution for the past two and a half years. The following conclusions may be drawn from this study.

1. None of the performance test ages or scores differentiated conclusively between the Adjusted and Maladjusted.

2. There is a marked probability that the Adjusted will always score higher on the Kent-Shakow Formboard 2S. There is a tendency towards a true difference between the Adjusted and Maladjusted in the Kent-Shakow Formboards 2D, and 3S, the Cornell-Coxe and the Witmer Formboard test ages. In these four tests the Adjusted scored higher than the Maladjusted The performance of the Adjusted is much like that of the Maladjusted in the Kent-Shakow Formboard 3D and the Witmer Cylinder.

3 The more difficult the performance test, the less does it differentiate between the Adjusted and Maladjusted This is well illustrated in the case of the Kent-Shakow Formboard series. With each successive form, that is, the more difficult the form becomes, the less it differentiates between the two groups The difference between the central tendencies of the Adjusted and Maladjusted decreases and the amount of overlapping between their distributions increases.

4. Both the Adjusted and the Maladjusted score higher on performance tests than on the Binet scale. On a simple performance test, such as the Witmer Formboard, the high-grade mentally deficient adolescent or adult scores on a level not much lower than that of the average for an unselected group. However, on more complex performance scales, such as the Cornell-Coxe, the high-grade mentally deficient tends to score on a level nearer his own Binet general mental level

5 There is no evidence in the present study that a difference of four years between the Binet and all performance test ages is indicative of maladjustment or instability. However, there is evidence in this study that a difference of plus four years or more between the Cornell-Coxe performance and the Binet test age is indicative of maladjustment or instability

6. There appears to be a more consistent relationship between the Binet performance test age of the Maladjusted than the Adjusted. However, this difference between the two groups is not sufficiently high for diagnostic purposes.

7 The Kent-Shakow Graded Formboard series was found very valuable in the clinical observations of maladjusted individuals It is doubtful whether such clinical values may be expressed in terms of end-scores. However, it is significant to note that the Kent-Shakow Formboard 2S has shown definite indications of possessing differentiating qualities with regard to social adjustment In the Kent-Shakow series there was found to be greater consistency in the performance of the Adjusted than of the Maladjusted.

In conclusion, there is evidence in this study that performance tests and scales may be used to considerable advantage in the diagnosis of maladjustment or instability in high-grade mentally deficient boys In this respect, the performance scale seems to be superior to the relatively simpler performance tests of the Witmer Formboard type. The results of this study suggest the need for further research on the value of performance tests and scales in the diagnosis of maladjustment or instability in individuals functioning on an average or above average general mental level.

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ADULT STATUS OF HIGHLY INTELLIGENT CHILDREN*

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THE PROBLEM STATED

The present study originated in the attempt of the Institute of Educational Research, at Teachers College, to establish "tops" for tests of adult intelligence and of mental work. In pursuit of this aim, in May, 1934, the cooperation was secured of two boys who in childhood had tested at 190+IQ and 188+IQ, respectively, by Stanford-Binet (in neither case having been fully measured, however, because of having "gone through the top" of Stanford-Binet when first tested at the age of nine years). These boys are recorded as Child 1 and Child 2, in Table 1 of this study.

These two boys, being tested at 21 years 0 month and 19 years 6 months of age, respectively, "found the tops" so far established on the CAVD Tests of the I E R series (18), and also approached the limits of the available tests of General Culture and of General Scientific Information, hereinafter to be described.

This consistency with childhood's performances, twelve and ten years earlier, stimulated the investigators to seek the cooperation of other persons who had been tested in childhood, of various degrees of intelligence above the average Five specific questions were formulated. (1) To what extent is status on CAVD at maturity predictable from status on Stanford-Binet in childhood? (2) What is the extent of difference in General Culture and in General Scientific Information at maturity, between persons who tested above 180 IQ (S-B) in childhood and those who tested at lower levels in childhood? (3) Is any consistent specialization in mental abilities discernible, from childhood to maturity? (4) At what degree of intelligence, in terms of IQ (S-B), is the word "genius" justified, if at all? (5) At what point on the scale of IQ (S-B) obtained in

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childhood will individuals later prove "unmeasurable" by available tests of adult intelligence?

PREVIOUS LITERATURE OF THE SUBJECT

The literature dealing precisely and verifiably with the development of the highly intelligent is as yet very fragmentary. It has been summarized in a recent study by one of the present investigators (12). Baldwin and Stecher (1) studying children clustering around 120 IQ (S-B) showed that such children remain constantly above average, as they approach maturity. Terman (15) has proved that 292 children testing above 140 IQ (S-B) earned high scores in group intelligence tests, as adolescents. Hollingworth and Kaunitz (12) found that 116 young children, testing in the hundredth centile by S-B, maintained their status in the top three centiles of the white draft on Army Alpha, in its various forms, when past 15 years of age, though not yet fully mature Duff (9) followed 73 children of IQ above 136, and found them four years later to be superior in scholastic studies, in teachers' ratings and in other respects, but he did not retest them.

THE PERSONS TESTED

In 1922, a group of young children then seven to nine years old, testing at or above 130 IQ (S-B), were identified for purposes of educational experimentation at Public School 165, Manhattan, in New York City (3) The mental status and accomplishment of these children were made matters of permanent, cumulative record. During 1934 and 1935, 18 of these persons took the tests formulated for adults, hereinafter described, at the request of the investigators To these were added three other persons, who had tested above 170 IQ (S-B) in childhood. The persons are numbered here, in Table 1, in accordance with the numbers assigned to them in a previous study (12), the three not there included being assigned letters Child E is from the research files of one of the present investigators (11). Child D has been previously reported by Terman (14). Child E B. is from the records of Stedman (13), IQ's (S-B) of 175 and 214 having been found at various times during childhood. E.B 's performance at maturity rates her with our children who tested between 170 and 180 IQ (S-B), and we have therefore considered the first rating of 175 IQ to be correct in her case

TESTS GIVEN IN CHILDHOOD

The children herein observed during development were measured in 1922 and subsequently by means of a wide variety of physical and mental tests (16) For purposes of the present study, we have assembled first Stanford-Binet, Stanford Achievement Tests given in 1924 or early in 1925, Army Alpha Tests at irregular intervals, and CAVD tests (given in a few instances in immaturity). Status in these tests is proved against status in the tests given in 1934 and 1935, *when the persons were at or near maturity.*

TESTS GIVEN AT MATURITY

The tests used in this survey, at maturity of the persons tested, were the I E.R Intelligence Scale CAVD, Levels N-Q, in one of the newly standardized objective-type forms (18) ; The Cooperative General Culture Test, Form 1933, or Form 1934; The Cooperative General Science Test, Form 1933, the Bernreuter Personality Inventory, and the Strong Vocational Interest Inventory. This paper is concerned only with the tests of intellect, culture, and scientific information The I E R. Intelligence Scale CAVD is a power intelligence test, given without time limit,[1] and developed primarily as a research instrument in the measurement of intelligence (17). The Cooperative Tests of General Culture and of General Science are parts of a large battery of achievement tests developed by the Cooperative Test Service, for use by the Committee in Educational Testing, a sub-committee of the Central Committee on Personnel, of the American Council on Education, in connection with its purpose of encouraging the use of standardized tests in high schools and in colleges (4, 5). The reliabilities of these three instruments are very high · .9287 (split-half raised by Spearman-Brown formula) for the General Science; .9782 (split-half raised by Spearman-Brown formula) for General Culture, Form 1933, and 9086 (alternate forms) for the I E R Intelligence Scale CAVD

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[1] It is necessary to state here that the CAVD test calls for "unlimited time" Our subjects had "unlimited time" only in the sense that they were allowed eight hours in which to accomplish all of the tests here mentioned Strictly speaking, their time for the CAVD was confined to whatever was left from performance of the time-limited tests, in most cases about four hours This restriction applied to all of those herein compared, so that our comparisons herein made relate to uniform conditions, but somewhat higher scores for some or all might have been obtained had the subjects been allowed to work till they had stated that they could do no more

RESULTS

In Table 1 are presented the data accumulated from examinations made in childhood, as well as the data collected currently, and the present educational status of the subjects The General Culture, Form 1933, scores were converted to 1934 values by means of equivalence tables (6).

In order to interpret the end tests of the current study, percentile tables were prepared, based on senior and junior classes of colleges participating in the Cooperative Testing Program for General Science, Form 1933 (7), for General Culture, Form 1934 (8), as well as a table of quartile points for selected populations tested by CAVD (Table 3).

For 16 of our cases there are complete data for (1) first Stanford-Binet IQ, (2) the last Army Alpha given, (3) the CAVD at maturity, (4) Cooperative General Science Test, and (5) Cooperative General Culture Test. For these 16 cases, all the intercorrelations were computed These intercorrelations are reported in Table 2

The correlation of the Stanford-Binet IQ (one trial only) taken at ages seven to nine, with Army Alpha (one trial only) taken at ages 16 to 19 is as high as the correlation of the Stanford-Binet IQ and the CAVD at maturity Considering the fact that the reliability of the Stanford-Binet declines in five years from 889 to 698, according to the formula $z = 1.415 - .00916t$ where $z =$ Fisher's function, $\frac{1}{2}[\log(1+r) - \log(1-r)]$ and t is the time in months (19), and that this diminution of the correlation between Stanford-Binet IQ's with the lapse of time has been found by various investigators (2), we can estimate that the correlation between Stanford-Binet IQ and CAVD, freed from attenuation, is about 85. This correlation is indicative of the fact that the early IQ (S-B) and the CAVD are essentially measurements of the same basic community of function By the same argument, the relationship between IQ in childhood and Army Alpha in adolescence is indicative of a similar community. For these gifted individuals (albeit there are so few studied) superior status on the Stanford-Binet at or near ages seven to nine is highly predictive of status on Army Alpha at or near 16 to 19 years of age, and of status on CAVD at or near maturity.

TABLE 1

THE TEST SCORES OF KNOWN HIGHLY INTELLIGENT CHILDREN AT DISCOVERY, AT LATER AGES, AT OR NEAR MATURITY

			Stanford Achievement Tests									
			Reading Par mng		Reading Sent mng		Reading Wd. mng		Arithmetic			
									Computation		Reasoning	
Child	First S-B IQ	Age First S-B	EQ	AQ	EQ	AQ	EQ	AQ	EQ	AQ	EQ	AQ
1*	190+	9-3	163+	85	164	86	168	88	168	88	180	95
2*	188+	9-4	183	97	187	100	189	100	165	82	197	105
E	187+	8-4										
3	187+	6-6	158	84	175	94	175	94	152	82	185	99
D	183+	7-5										
E B	175	5-0										
7**	174	7-5	155+	89	151	87	152	87	161	95	149	85
8	173 or 177	7-1	180	104	185	107	190	110	171	99	161	93
9	172	7-4	149	87	199	116	139	81	173	100	183	106
14	168	7-2	162	96	154	92	169	101	171	102	163	97
15**	168	9-9	162	96	156	93	156	93	155	92	158	94
16	167	9-0	164	98	164	98	164	98	151	90	170	102
18	164	8-7	157	96	156	95	138	84	164	100	155	94
20	162	8-8	172	106	166	102	160	99	155	96	134	83
23	160	7-8	177	111	172	108	168	105	159	99	159	99
26	158	9-7	147	93	147	93	147	93	154	97	163	103
53	151	8-6	164	108	151	100	151	100	136	90	141	93
68	145	9-4	152	105	152	105	137	94	162	112	130	90
67	145	9-3	161	111	157	108	163	112	156	108	153	105
95	138	8-7	144	105	147	107	135	99	162	118	142	104
115	133	7-8										

TABLE 1 (*continued*)

Stanford Achievement Tests

	Nat study + Sci		Hist + Lit		Lang usage		Dict	Spel.	Composite	
Child	EQ	AQ	EQ	AQ	EQ	AQ	EQ	AQ	EQ	AQ
1*	170	89	164	86	159	84	182	96	171	90
2*	173	91	179	95	175	93	203	108	184+	98
E										
3	162	87	172	92	151	81	163	87	168	90
D										
EB										
7**	152	87	146	84	146	84	166	95	154	88
8	167	97	177	102	182	105	171	99	175	101
9	158	92	190	110	132	77	177	103	193	112
14	176	105	176	105	173	103	187	111	171	102
15*	138	82	152	91	151	90	156	93	154	92
16	154	92	163	98	160	96	181	108	164	98
18	145	88	145	88	148	90	144	88	151	92
20	148	91	162	100	161	99	155	96	155	96
23	157	98	164	103	162	101	159	99	163	102
26	141	89	147	93	144	91	150	95	150	95
53	138	91	142	94	162	107	136	90	144	95
68	114	79	136	94	129	89	144	99	139	96
67	152	105	156	108	159	110	173	119	159	110
95	123	90	140	102	137	100	162	118	144	105
115										

TABLE 1 (*continued*)

Child	Army Alpha	Age	Early Army Alpha	Age	Army Alpha	Age	Army Alpha	Age	Army Alpha	Age	CAVD	Early Age	CAVD	Age
1*	186[7	11- 4	202[5	15-7			210[8	19- 6			435	15-7½	446	18-2
2*	163[7	9- 1	202[5	14-6			198[8	18- 2			428	12-5		
E	201[6	13- 0	194[5	13-0							441	18-9		
3	76[5	7- 6	128[5	9-6	162[7	11-6	204[8	17- 7	205[	18-6	422	17-0		
D	185[5	10-11												
E B														
7**							192[5	17- 6						
8							181[5	16- 1						
9	129[7	10- 0					185[8	18- 2						
14	111[7	9- 6					191[8	17- 7						
15**							193[8	19- 8						
16	142[7	10-11					197[8	19- 1						
18	124[7	11- 1					194[8	19- 3						
20	151[7	11- 1					192[8	19- 3						
23	130[7	10- 2					188[8	18- 4						
26	124[7	11- 4					186[8	19- 6						
53	118[7	10- 5					183[8	18- 8						
68	125[7	11- 4					159[8	19- 7						
67	128[7	11- 1					193[8	19- 3						
95							166[8	18-11						
115							183[5	17- 6						

TABLE 1 (*continued*)

Child	CAVD	Current Study Gen Sci.	Gen Cult.	Age	Educational status
1*	454	153.0	713.33	21-0	B.A. + 1 yr med. school, ΦBK, major, pre-medical
2*	439	92.25	536	19-6	H S grad + part of a semester in college
E	445	68	641	26-4	B A, M.A, Ph D, major, History, ordained clergyman; ΦBK.
5	435	120.75	389.	20-9	B A, in 1st year grad work; major, Statistics and Economics
D	444	136	603.33	24-6	B A + 3 yrs grad work in Physics, ΦBK· research physicist
E B	438	62.50	489.5	21-1	B A + 1st year grad work; major, Social Science
7**	435		528	21-6	B.A, major in English
8	435	59	519.	20-5	B A
9	429	145.5	288	20-2	B A., M A, Chemistry and pre-med + 1 yr med school
14	425	142.25	284	19-7	B A major pre-med + nearly 2 yrs med school, ΦBK.
15**	431	45.25	443.	21-8	Three years college, major, Economics
16	423	60	524	21-0	B A, major, Philosophy
18	428	85	235.	21-2	B A, major, Botany
20	429	164.75	422	21-1	B A + 1st yr grad work, major, Science
23	428	47.75	351.42	20-7	B A, major, Sociology
26	421	41.50	299.33	21-9	B A + 1st yr law school; major, Sociology.
53	423	36.5	282	20-7	B A + 1st semester grad work, major, German and Educ.
68	421	24.25	301	21-6	B A + 1st year grad work in Political Science
67	425	123.25	474	21-1	B A, major, Chemistry.
95	412	50.5	262.5	22-3	B A
115	431	59.75	396	20-8	B.A, ΦBK

*Off scale in most of the Stanford Achievement Tests

**Too old to be fully accounted for on Stanford Achievement Test, at the age when achievement was given

TABLE 2

The intercorrelations among the five variables (1) first Stanford-Binet IQ, (2) last Army Alpha given, (3) the CAVD at or near maturity, (4) Cooperative General Science, and (5) Cooperative General Culture, for 16 cases for whom complete records were available

Variable	2	3	4	5
1	68	67	45	47
2		62	59	52
3			44	75
4				26

In reference to the Cooperative Achievement Tests, it is clear that CAVD is more closely associated with General Culture than with General Science. This is most vividly demonstrated by the percentile values for the two tests. The range in percentile for General Culture is from 72 to 100 or > and for General Science from 10 to 100 or >. There obviously is a specificity of success for Science as compared with General Culture. The correlation between these

TABLE 3

THE PERCENTILE VALUES OF CERTAIN TESTS USED WITH KNOWN HIGHLY INTELLIGENT CHILDREN AT OR NEAR MATURITY IN TERMS OF SPECIFIED POPULATIONS

	General Science Form 1933		General Culture Form 1934		I. E R Intelligence Scale CAVD		
	Juniors	Seniors	Juniors	Seniors	Teachers college A M candidates	Law school freshmen	Law school freshmen
100	172	157	479	626			
98	134	123	416	488			
93	103	89	347	350			
90	96	74	321	316			
84	81	66	282	279			
80	75	60	268	264			
75	66	58	241	239	422	421	425
70	61	55	228	227			
60	56	50	206	206			
50	47	42	168	184	415	415	421
40	44	38	145	163			
30	41	35	126	140			
25	37	30	113	124	410	409	416
20	32	30	101	114			
16	30	28	91	108			
10	25	21	74	94			
7	23	19	67	84			
3	19	12	54	69			
1	13	1	44	61			

two variables of 26 may be interpreted through the coefficient of alienation as indicative of this specificity

The results for the CAVD as interpreted through the norms obtained on selected populations show that highly intelligent children (of IQ 140 and above) fall within the upper quartile of the college graduate population of the United States, when they are at or near maturity.

CRITIQUE OF THE CONCEPT OF "GENIUS" AS APPLIED IN TERMS OF IQ

The term "genius" has been used by Terman (15), and following him by many others, to denote children testing at or above 140 IQ (S-B) In the light of the developmental data herein presented, it would appear that the term "genius" is thus misapplied, unless we wish to define as "geniuses" persons who represent approximately the best fourth of all students graduating from American colleges

Of individuals here followed to early maturity, those who test at about 140 IQ (S-B) are found to define approximately the 75th percentile of college graduates, taking it the country over They are far from "genius," if by that term is to be meant the degree of mental ability that is capable of outstanding original intellectual achievement. It is only when we have an IQ (S-B) of at least 160 in a child, that we may begin to expect mildly noteworthy accomplishments, such as the winning of "honors" in a first class college. Very rarely are "honors" won in first class colleges by those who test below this status in childhood The small sample of college graduates here presented is truly representative of the much larger sample in our files (not tested by our end tests) in this respect

Of primary interest to the present investigators is the subsequent history of those who in childhood have achieved the extremely infrequent rating of 180 IQ or higher. At maturity, will these persons still stand out from their contemporaries in mental tests and in achievement?

This question is answered affirmatively by our data The five children here included, who achieved IQ's (S-B) on *first* test in childhood of more than 180 are they who "find the tops" on CAVD, at maturity. Every one of these top-rank persons is noteworthy among contemporaries Before the age of 22, in all cases, one had prosecuted research in history, one in mathematics; one in chess. Two had become established in learned professions. One stood high in the national ranking for chess A long list of medals and prizes had been won by them All but one of those graduated from college had been elected to Phi Beta Kappa

These unusual achievements show how children testing above 180 IQ rise above the generality of the college populations, in adolescence and in early maturity. None of those who tested in childhood around 140, 150, or 160 IQ (S-B) approaches these in honors and prizes won, or in test scores, at maturity.

This is, perhaps, the most significant fact to be derived from our data. that the children who test at and above 180 IQ constitute the "top" among college graduates. They are the students of whom *one may confidently predict that they will win honors and prizes,* for intellectual work

Furthermore, it is shown that at approximately 190 IQ (S-B), individuals "go through the ceiling" of available tests for adult intelligence, by the time they are 21 years old. We cannot at present distribute these persons, at maturity

Perhaps this is the point at which the term "genius" begins to apply, i e, at or near IQ 180 (S-B), if we adhere to the dictionary definition of the word, "Exalted intellectual power, marked by an extraordinary faculty for original creation, expression, or achievement" (10), which is beyond the reach of available modes of measurement, in its maturity[2]

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[2] "The Dictionary of Psychology" (20) defines "genius" in terms of IQ in part, i.e, "genius = a very superior mental ability, especially superior power of invention or origination of any kind, or of execution of some special form, such as music, painting or mathematics . It has no special technical meaning, but has occasionally been defined as equivalent to an intelligence quotient (IQ) of 140 or above"

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SHORT ARTICLES AND NOTES

BEHAVIOR OF WHITE RATS IN A MAZE REQUIRING DELAYED RESPONSE*

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The experiment reported here is concerned with the behavior of white rats on a maze requiring delayed response, analogous to that described by Carmichael and Marks (1)

The maze, made of portable segments 24 inches long by 2 inches wide, elevated 18 inches above the floor, was arranged as shown in the accompanying diagram It may be considered as two mazes with a common segment If the rat is started at *A*, it can obtain food only by following the path designated as *A*1, *A*2, *A*3, etc This may be called Maze *A*

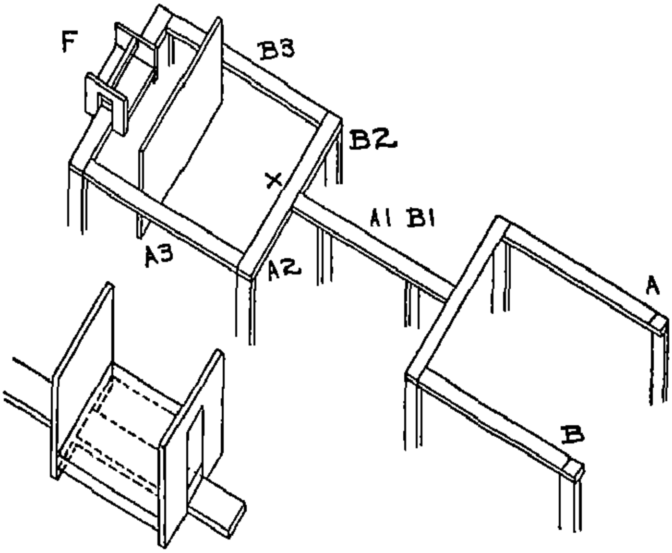

FIGURE 1

If started at *B* it can obtain food only by following the path designated as *B*1, *B*2, etc. This may be called Maze *B* The food box, located at *F*, was constructed so that the rat's access to it was from one side only, the position

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*The writers acknowledge indebtedness to Professor Leonard Carmichael, who suggested the experiment, and to Mr B. H Riskin who carried out preliminary trials of the accessible side being alternated in accordance with the maze response, *A* or *B*, which the animal, at the moment, was expected to make. A screen of composition-board, 8 inches by 20 inches, mounted on a standard separate from the maze, was so placed as to cut off the view of the food box from any part of the common segment (*A*1*B*1).

The animals were without food 22 to 23 hours preceding each day's trials During the trials each animal was allowed to eat at the food box for 10 to 20 seconds after each correct performance All were fed at the conclusion of the experimental session The food was McCullom's diet (2, p 55), to which had been added powdered skim milk, one part in eleven. It was fed uncooked, as a mixed meal. The quantity varied from two to six grams daily to each rat, according to the condition and performances of the animal. At the beginning of training it was two grams, but was increased as training progressed until the optimum consistent with the best performance and condition of each animal was found. A small quantity of fresh lettuce was also fed daily

The experiment was carried out in a third-floor room, lighted only by a single 40-watt light, suspended (owing to a rather low ceiling) approximately 30 inches above the center of the maze. On the 19th experimental day this lamp was shielded with an inverted shade which reflected the light to ceiling, thus substituting indirect for direct lighting Under the previous arrangement the performances of the animals had appeared to be slightly affected by the proximity of the source of light

The animals were kept in one locality in the room in which the maze was situated They were carried by hand from the living cage to the starting point of the maze. The time required for the animal to traverse the maze from starting point to food box was taken with a stop watch. Errors consisted of any deviations from the true path of the maze, *A* or *B*, on which the animal had been started. An error was counted if the head and forelimbs of the animal crossed the junction of a segment which was not a part of the true path for that particular trial Retracings were also counted as errors, one error for each maze segment traversed in the wrong direction

The duration of the experiment was 54 days. The initial training series, carried out with six male rats, 120 days old, consisted in training the animals to traverse maze *A* until they had reached the criterion of learning which had been chosen—13 consecutive trials without error When the criterion had been reached on maze *A*, the rats were trained on maze *B* When *B* had been mastered they were retrained to the criterion on *A*; then again on *B* to the criterion. At this stage of the experiment only three of the six animals succeeded in reaching the criterion These three animals were then required to run both mazes according to an irregular pattern of alternation. If the animal began the day's trials on *A*, the sequence of the

12 trials was *A B B A A A B B B A A B* If it began on *B*, the sequence was the reverse, i e., *B A A B, etc.*

Of the three animals which successfully reached this stage of the experiment, Rat 1 began a series of nine consecutive trials without error at the 35th trial of irregular alternation (189th of the total series) It made a further record of 12 consecutive trials without error beginning with the 45th trial of irregular alternation (199th of total series), and a final record of 80 without error beginning at the 127th trial of irregular alternation (281st of the series) The average performance times of this animal were (*a*) for the first ten trials of irregular alternation, 7.07 seconds with a mean variation of 2.29 seconds; (*b*) for the first nine consecutive trials without error, 3.9 seconds with a mean variation of 25 seconds; times for subsequent series without error did not vary significantly from this

Rat 2 began a series of eight consecutive trials without error at the 15th trial of irregular alternation (204th of the series). It made a further record of 15 consecutive trials without error beginning at the 55th trial of irregular alternation (245th of series) Average performance times of this animal were: (*a*) for the first ten trials of irregular alternation, 4.9 seconds with a mean variation of 1.4 seconds, (*b*) for the first eight consecutive trials without error, 4.0 seconds with a mean variation of 9 seconds, this value being representative of subsequent correct performances

Rat 3 made two sets of five consecutive trials without error beginning at the 34th and 49th trials of irregular alternation (214th and 229th of series) but had not exceeded this record by the 78th trial of irregular alternation, when it became necessary to discontinue the experiment Average performance times of this animal were (*a*) for the first ten trials of irregular alternation, 6.9 seconds with a mean variation of 3.2 seconds; (*b*) for the first set of five trials without error, 3.6 seconds with a mean variation of 14 seconds The other series did not vary significantly from this

Errors made during the trials with irregular alternation were of various sorts Miscellaneous errors, possibly irrelevant to learning, occurred in the earlier parts of the experiment, apparently because of the retention of particles of food by the animal from its feeding at the conclusion of a preceding correct trial These were reduced by taking care that the rat had no food in its mouth when starting a new response. Another type of error, more significant to learning, appeared relatively early in the irregular alternation series, and also later on occasions when the animal appeared to have been slightly disturbed The rat would run from the starting point of the *B* response to the starting point of the *A* response, and then try to complete the *A* response. The majority of the errors relevant to learning, however, occurred at the critical point of the maze (+ of the diagram). The animal, running rapidly, would make a wrong turn at the critical point, but would stop before reaching the final segment on which the food box was placed, and would then run back, continuing past the critical point to the correct response These erroneous runs past the critical point shortened as learning progressed until stages were reached, just prior to mastery of the problem, in which the animals could be observed simply to stop at the critical point, turn the head to right and left, start with head and forefeet to the right, draw back, start to the left, draw back, continuing thus for several times before finally completing the response Occasionally they would run slightly beyond the critical point, stop, run back slightly beyond it in the opposite direction, reverse again, and so continue for several pendulum-like repetitions before concluding the response.

As learning approached mastery, however, this behavior gave place to a rapid, unhesitating form of response in which the animal exhibited signs of maintained orientation from the beginning of the response The rat "pointed" with nose, head, and forebody in the direction in which it was going to turn before each turn was made "Pointing" was exhibited before the animal had left the first segment of the maze, and was most manifest on the common segment before the critical point was reached

Clearly marked bodily orientation was not an invariably noted condition of a successful response, but it was characteristic of the majority of the successful responses, and it was not exhibited by animals which made no progress at the problem The inference may accordingly be suggested that in this delayed response of the rat, as in those studied by Hunter (3), maintenance of bodily orientation is, for some animals, an important condition of successful delay

McAllister (4) and Wilson (5) have reported delayed responses of rats under conditions similar to the present ones in that the animal is moving during the period of delay Both of these investigators consider that in some of their successful animals bodily orientation was not maintained during the period of delay "Reaction in the situation present in this study," McAllister notes (4, p. 101), "was found, at least in some cases, not to be on the basis of overt bodily attitudes." However, of the 25 rats trained in his situations, four only appear to have been able to develop successful delayed responses in the face of obstacles (such as being required to dig through sand, or to go through a 180-degree reversal of their path) which could be regarded as adequate controls of overt bodily attitudes

Wilson states (5, p. 47) in reference to successful delayed responses secured by him, "Gross motor posturing is not necessary for effecting the delayed response in this problem, since the animal was required to traverse a distance varying from 8 to 60 inches during the delay period" It is possible, however, that mere variations in distance traversed are not a sufficient check against overt bodily attitudes in the animal. It is to be noted that behavior characteristic of the successful delayed response under

Wilson's conditions, as he himself states, is "behavior which is continuous and leads toward the goal without interruption or emotional disturbance," and, conversely, that difficulty develops when there is: (*a*) "forced interruption of activity during delay," (*b*) "spontaneous interruption of activity during delay," (*c*) "punishment either by shock or confinement"—all three conditions being such, presumably, as would impair or shatter maintained bodily attitudes.

It may indeed be true that some rats are capable of successful nonpostural delayed responses, but it would seem probable that such responses lie close to the upper limit of the animal's capacities and are less characteristic than responses made on the basis of overt bodily attitudes.

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MAZE LEARNING AS PERCEPTION

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Because of the growing tendency to think of problems of perception and learning as identical, it seems desirable to examine empirically the utility of such a viewpoint. The systematic advantages of such a simplification of laws and entities are tempting, but the ultimate test of the assumption of likeness between learning and perception must be its usefulness. During a recent investigation (6) of the relative difficulty of various patterns of ten-section Warden multiple-U mazes it was found that the relative number of entries into the various blind alleys could have been much better predicted from configurational theories of perception than from any current theory of maze learning known to the author. It is the purpose of this paper to make a brief analysis of the data in one of the seven mazes used in that experiment and to report new experimentation suggested by this analysis

In the earlier investigation (6) 13 white rats were tested in the control *B* maze, an all-black Warden multiple-*U* maze of the standard LRRRLL-RLLR pattern (4) An equivalent group was placed in the experimental *B-W* maze, spatially identical to the *B* maze but with the walls and floor of the blind alley half of each section painted white Using a criterion of three out of four perfect runs the animals in mazes *B* and *B-W* learned their respective mazes in medians of 34 and seven trials respectively All animals were, however, run for 45 trials and were then placed in the spatially identical "twin" maze. Group 1, which had been trained in the all-black *B* maze, was thus transferred to *B-W* and Group 2 to *B*

In view of the challenged (10) theory that "rats turn to kinaesthetic cues and habits once the maze has been mastered," the performance of Group 2 in their first trial in the *B* maze was watched with interest These animals had run 45 times in the spatially identical *B-W* maze, an average of 38 trials of overlearning During their last 25 trials they had been correct in 99 6 per cent of their choices If there is any tendency for relegation to kinaesthetic cues to take place it should be manifest in such a group In any case where the animal had turned completely to such cues in the *B-W* maze it does not seem illogical to expect a perfect performance in the first attempt at maze *B*.

Of the 13 animals, one (M22) did make such an errorless run, although even he showed a marked rise in performance time The other animals made from four to 26 errors each It must be considered that the performance *of M22, in a room where the extra-maze stimuli were unfamiliar*, can indicate nothing but dependence upon the common feature of both mazes, their spatial pattern. There still remained the possibility that the other animals may have been prevented from using the same method by distracting features of the new situation If so, they should have made a rapid improvement to errorless performance as soon as they became accustomed to the new conditions This did not occur The median trial at which this group learned the *B* maze was the 45th, while the untrained group 1 had met the same criterion at the 34th trial This would indicate that 12 out of the 13 rats could not run correctly a spatially identical maze under different sensory conditions, even after considerable overlearning

However, animal M22 had obviously responded to pattern or he would not have been able to run maze *B* without error on his first trial It is not necessary to assume, however, that such response to maze pattern implies kinaesthetic control or that it is the final stage in learning At the 40th trial in maze *B* the first and second sections of the maze were interchanged. At this point M22 had made 73 consecutive errorless runs, 34 in *B-W* and 39 in maze B If the performance were controlled by kinaesthesis the shift in the two sections would have had no effect If the performance were controlled in the same way as it had been on his first trip through the maze the transposition would have had no effect In following the correct path in this LRR,RLLRLLR maze the first turn is to the left and the second to the right When the starting-box door was lifted the animal, after having turned left at this point for 73 consecutive trials, now *turned right, making the response appropriate to section 2 in its former position* The turn was made without hesitation and carried the animal well around to the end of the blind alley He then turned, went to the entrance of the next section and there made the response appropriate to its former position, a left turn The rest of the run was made without error Of the 13 animals in the group, six made errors in the shifted sections on this run although none had erred in this part of the maze during the preceding eight trials In addition one other animal who customarily made errorless runs made three errors farther on in the maze. One animal made a perfect run in spite of the change. The other three animals unaffected by the transposition had failed to learn the maze

The implications of these results are plain An animal formerly able to run the maze without differential sectional cues other than possible proprioceptive ones had come to rely upon localized cues in his performance. The animals able to run the shifted sections without error were, with one exception, animals who had failed to learn the maze In this case maze learning appears to be closely associated with the increasing differentiation of the various sections Complete differentiation to the point where the individual sections are clearly distinguished is not necessary in this maze but the tendency is for the differentiation process to continue to that point.

This view of maze learning as perceptual differentiation is in full agreement with the findings of Perrin (5) in his investigation of maze learning by human subjects. He reports, "Two chronological stages were in evidence in the conscious part of the learning. The subject was guided in the first few trials by a general scheme of direction, gained when the exit was reached for the first time He then found that in order to perfect his route a number of separate segments, presenting special problems, must be studied"

Where the gross differentiation of general direction which Perrin names as the *first stage* is adequate for perfect performance, as in an LLLLL-LLLLL maze (6), errorless performances were made almost at once Of the nine rats trained in this maze, two made no errors after the first trial and no animal entered a blind alley after the third trial The mazes in which the correct path was differentiated by shade from the blind alleys so that the maze could be run by following a white or black path without specific recognition of any section or turn were also run perfectly by some animals on the second trial and by the majority on the third or fourth

In the standard type mazes, as *B*, more complete differentiation would be necessary, i e., recognition of each turn or at least of those turns where a change of sequence takes place Thus in the *B* maze

L R R R L L R L L R
1 *2* 3 4 *5* 6 *7* *8* 9 *10*

these critical turns would be at sections 2, 5, 7, 8, and 10 Once the animal has become aware of a goal and its general direction from the starting box, the maze must be further differentiated into five segments or sub-problems, each one having for its immediate goal the finding of the critical section Results published by Spragg (8) indicate that when such a critical turn is successfully made there is an abrupt decrease in errors in the immediately following sections The animal has, by the successful completion of one sub-task, become orientated for the attack on the next

TABLE 1
ERRORS PER SECTION, MAZE *B*

	Trial	Section										Total
		1 L	*2* R	3 R	4 R	*5* L	6 L	*7* R	*8* L	9 L	*10* R	
Group 1	2	4	9	3	3	5	4	7	6	7	7	55
	12	2	2	2	4	2	2	4	4	4	3	33
	22	1			6	1				2		10
	32	1			6	2	2	2	1	4		18
	45	1			5					2		8
Group 2	2	4	3		3	3	1	6	6	7	6	41
	12		1		9		5	5	2	11	4	37
	22	1			3	1	6	3	2	6		22
	32	1	1		5	3		4		7		21
	45	1			5		1	4		4		15

In any maze the differentiation of the goal out of the situation is indicated by the tremendous drop in performance time of the second trial as compared with the first. The early discovery of the general direction of the food box is evidenced in uni-directional mazes by the rapid drop in retraces, retracing being rarely found after the fifth or sixth trial (4)

A table of the distribution of errors made in the various sections of maze *B* strikingly shows the progressive differentiation into sub-mazes postulated above

The inadequacy of any view of maze learning as simply elimination of errors is at once evident Some errors are learned rather than eliminated In both groups more errors were made in section 4 on the 45th trial than on the second, in spite of the fact that the errors on the 45th trial were made only half as many animals, half of each group having already learned the maze

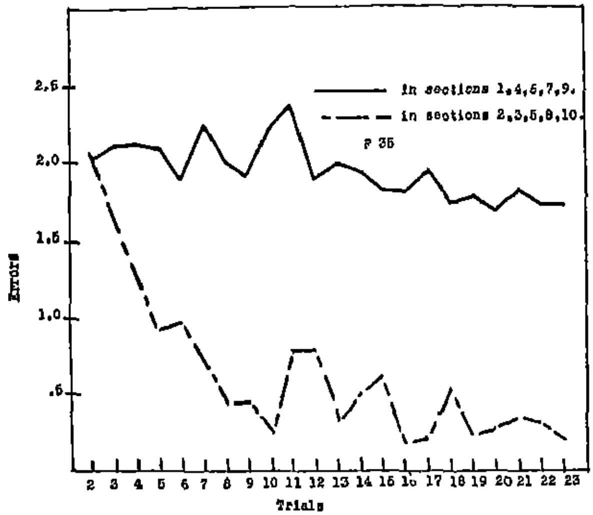
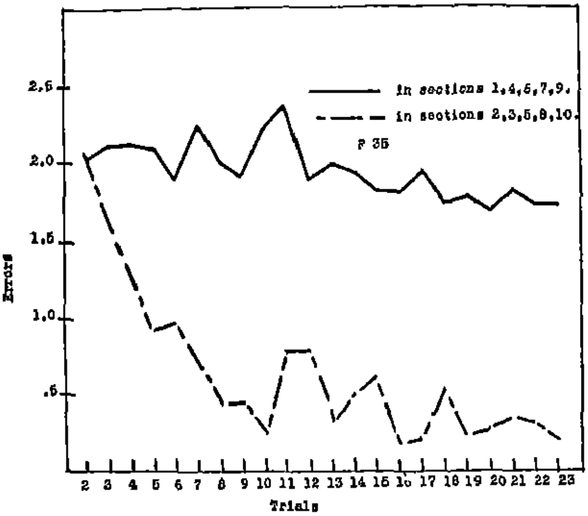


FIGURE 1

essential part of the process of learning the maze Once this is done the maze can be run without error by the further differentiation of the crucial sections 2, 5, 7, 8, and 10 to the point where they can be recognized by definite cues The success of some animals in negotiating the maze when the sections have been shifted indicates that these cues may be proprioceptive The evidence is quite definite, however, that the best performers came to recognize the critical sections by exteroceptive cues Of the animals undisturbed by the shift of sections 1 and 2 mentioned above, only one animal had learned the maze, although all had learned that portion of it

If the chief difficulty of maze learning is, as this leads us to suppose, the perceptual differentiation of the critical turns, any cues placed in them will accelerate learning Spragg (7) ran four rats in a Walton *U* RRRRRRRL pattern and found that none of them learned in 100 trials In the last five trials 12 of the 15 errors were made just before the crucial last section To investigate the effect of visual cues we placed white crayon in the tenth section of a Warden *U* LLLLLLLLLR maze All of the eight rats used had fulfilled the criterion of learning (three perfect runs out of four trials) by the 69th trial When the cue was emphasized by placing a section having a white blind alley in the crucial position all four of the rats tested learned within six trials Any maze in which the critical sections are clearly differentiated, either visually or otherwise, should be learned in fewer trials than a spatially identical maze in which the sections are homogeneous.



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To test this hypothesis, two mazes were set up, one the standard all-black *B* maze, the other a maze of the same pattern and dimensions in which the critical sections were painted white and the others black. Nine rats, paired for sex and litter mates, were run in each maze Using the usual criterion (3-4) maze *B* was learned in 29 trials, the experimental maze in 12. Only one animal learned the control maze as early as the median trial in the experimental maze The trials at which the criterion was satisfied for the individual animals were:

Experimental: 6, 6, 8, 10, 12, 13, 13, 14, 16
Control 10 14 18 28, 29, 31, 32, 34, 45 plus

Furthermore, if our hypothesis is correct, it should be possible to alter the number of non-critical sections in a sub-maze without causing errors by animals using exteroceptive cues In the *B* maze pattern section 3 is non-critical and section 5 critical.

1	2	3	4	5	6	7	8	9	10
L	R	R	R	L	L	R	L	L	R

If the animals in the experimental group had differentiated the maze into the sub-problems we have postulated we should expect them to make a specific response to 5, which must be well differentiated for errorless performance, and a non-specific response to section 3 Accordingly each animal in the experimental group, after meeting the criterion of learning, was tested with the maze sections shifted so that 3 followed 5

1	2	4	5	3	6	7	8	9	10
L	R	R	L	L	L	R	L	L	R

Of the nine animals, seven made the specific (left) response at 5, and all turned left at 3, making the response appropriate to its new position in the "left" sub-task following 5 instead of the "right" response demanded by its former position in the pattern Although seven of the nine rats thus ran the changed portion of the maze without error, it is not surprising that four of these then turned right at section 6 The short 6-7 sub-maze hardly requires visual differentiation between the sections. Accordingly the animals, accustomed to turn right at the second section from 5, now encountered the 3-6-7 sequence and turned right at 6 One of the remaining animals turned left at 7 and the other two ran the maze without error

A similar test of the animals in the control *B* maze gave similar results On the 47th trial section 3 was removed from the maze, leaving the pattern:

1	2	4	5	6	7	8	9	10
L	R	R	L	L	R	L	L	R

Of the eight animals who had learned the maze, six ran the new pattern without error, indicating specific response to 5 In this maze, however, section 5 would evoke this specific response only when in position at the end of its own sub-maze When placed after section 1 it evoked a "right" turn from every rat

SUMMARY AND CONCLUSIONS

Analysis of learning and errors in multiple-*U* mazes indicates that maze learning is a process of increasing differentiation from the total situation, during which the maze is first perceived as a general path to the food-box and is then differentiated into sub-mazes whose solution is dependent upon the further differentiation of those sections where a change in procedure is necessary. This hypothesis is supported by the finding that mazes constructed so that the final complete differentiation of parts is either aided or is unnecessary are learned more easily than standard mazes of the same length and number of turns. We have already found (6) that when the adequate response may be made, as in an LLLLLLLLL pattern maze or in a visual discrimination maze, not to the individuated parts of a situation but to a general feature or principle of the task, learning takes place much faster than when the more individuated response is required. The implication is that the less complete individuation is prior in learning, as Gestalt theories hold it to be in perception (1) In this case, at least, learning and perception can be considered equivalent.

Using the term "critical section" to denote any section where a change in procedure is necessary, the learning of homogeneous section mazes may be divided into three phases. In the first phase there is a decreasing number of blind alley entrances as each critical section is approached and the animals come to adopt the adequate procedure. Since this procedure is then incorrect for the critical section, the incidence of error in such sections is high During the second phase, that of sub-maze differentiation, the animals are able to make the correct response to each sub-maze sequence but cannot *distinguish its limit, the critical section. Consequently there is a tendency* to anticipate (7) and a rising incidence of error as the critical section is approached. Few errors are made in the critical section itself in this stage and as soon as the turn has been successfully negotiated it becomes the orientation point for the attack on the next sub-maze In the third phase the critical sections are differentiated from the sequence and no errors are made. On the basis of this analysis a regular decrease of errors toward the food-box would be found in single procedure mazes (mazes without a critical section) only and would occur there before the food-box is reached for the first time Experimental verification of this pre-goal elimination of errors, inexplicable by the goal gradient hypothesis, has already been published (6)

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COMPLEX VISUAL DISCRIMINATION IN THE CAT

C K TRUEBLOOD

This note reports experiments carried on in the Brown University Psychological Laboratory in an effort to secure information as to the possibilities of complex discrimination and allied behavior in the cat Three cats were trained in visually discriminative responses to a series of three stimulus situations analogous to those described by Dr H W Nissen in his study "Concurrent antagonistic visual discriminative habits in the chimpanzee" (1) The stimuli are represented in Figure 1

In Situation I the cat is required to respond positively to the large white square on the black ground, which is displayed on one or the other of the two doors of the discrimination apparatus (2) The cat approaches the door on which the positive stimulus is displayed and presses down a lever connected with this door The door then opens and the cat thrusts its head into the aperture and obtains food Food is placed behind both doors, the negative or incorrect door being locked Alternations in the position of the positive stimulus are made constantly though irregularly

In Situation II the animal is required to respond positively to the small black square on the white ground, in Situation III, to the large black square. When Situations I and II have been separately mastered, they are presented concurrently in irregular alternation If and when this stage is mastered, the animals are trained in Situation III Finally, Situations I, II, and III are presented concurrently

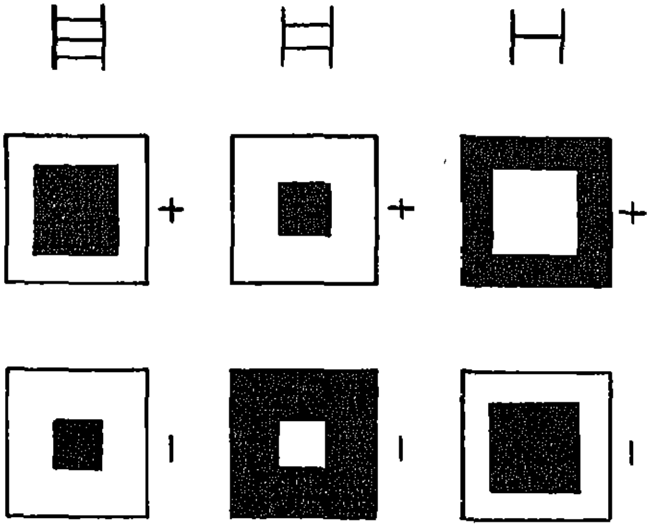

FIGURE 1

Situation I, taken alone, involves a relatively simple discrimination. The animal may respond simply on the basis of the black-white relations of the figure with its ground The response might take place on the basis of one stimulus only of the pair The animal might respond, that is, mainly *toward the positive stimulus, or its response might be mainly an avoidance* of the negative stimulus. Similarly, Situation II, taken alone, although it involves a reversal of Situation I, may be the same sort of relatively simple discrimination, taking place, that is, on the basis, simply, of the black-white relations of the figure with its ground and also, perhaps, involving *mainly one stimulus of the pair*

When, however, the animal is presented with Situations I *and* II concurrently, a more complex form of discrimination is at once necessitated When the large squares of Situation I are presented, the animal must respond positively to the white square, with the small squares of Situation II the animal must respond positively to the black square Continued success therefore requires that the animal's responses be relevant to at least two varying characteristics of the stimuli, namely, the relative size of the squares and their black-white relations with their grounds. Possibly also, the animal's response is relevant to the stimulus pairs as pairs

Furthermore, when Situations I, II, and III are presented concurrently, *it is clear that correct responses* by the animal must be relevant not only to the size of the squares, and to their black-white relations with their grounds, but to the stimulus pairs as pairs. For example, the small black square must be responded to positively when presented with the small white square in Situation II. It must be responded to negatively, however, when presented with the large black square in Situation III.

Of the three cats trained in this series of situations, one (Cat A) was discarded as giving little or no indication of capacity to master Situations I and II presented concurrently. Two animals, however, reached and were able to maintain a criterion of 90 per cent accuracy (18 out of 20 choices correct) in this problem. One animal, also, attained a criterion of 90 per cent accuracy when presented with Situations I, II, and III concurrently. It maintained this discrimination for five successive days, but its performances thereafter so seriously deteriorated as to require a return to discrete training in the separate situations. Unfortunately, before this animal could again be brought to the criterion for the three combined situations, it died in an epidemic which went through the colony.

The progress of the animals with these problems will perhaps be made more clear by a consideration of their performance graphs (Figures 2 and

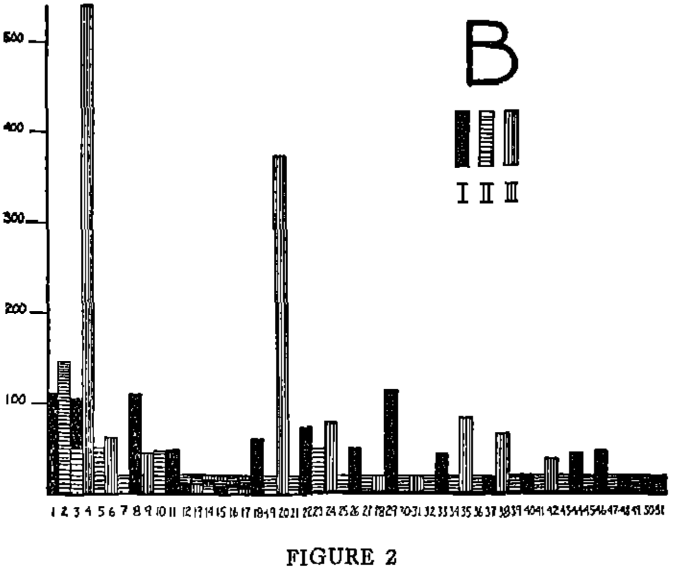

FIGURE 2

3). The graphs are drawn in the form of column diagrams, successive columns, left to right, representing the sequence and the total number of presentations of Situations I, II, and III, either singly or concurrently, throughout the experiment. Each column indicates one presentation, the height of the column showing the total number of trials required in that presentation to bring the animal to a criterion of 90 per cent accurate choices Thus column 1 (Figure 2) represents the first presentation of Situation I to Cat B, 112 trials being required to reach the criterion Column 3 represents concurrent presentation of Situations I and II, a total of 360 trials being necessary to bring the animal to this pitch of discrimination Columns 12, 50, and 51 also represent concurrent presentations of Situations I and II. Columns 13, 14, 15, 16, and 17 represent concurrent presentations of Situations I, II, and III over a period of five days, the percentages of accuracy being 85, 90, 95, 85, and 95. The trials necessary to bring the animal to this point of discrimination totaled 1450, and almost immediately afterward the animal's performance so far declined as to necessitate return to discrete training in the separate habits.

Interference effects may be seen by contrasting the height of column 1 representing the 112 trials which the animal required to master Situation I with column 2 representing the 146 trials required for mastery of Situation II, and with column 5 representing the 560 trials required for Situation III Interference is further evident in that after mastery of Situation III, re-establishment of I requires 110 trials as against 40 in the immediately previous presentation of that situation Interference was always more marked, for both animals, between Habits I and III than between I and II or between III and II. This fact is evident in the lower number of trials throughout required for II, its relatively consistent retention as contrasted with the variable retention of both I and III Furthermore it may be noted with respect to Habits I and III (columns 22 to 42) that as the trials to bring one habit to the criterion are reduced, the trials required to bring the other to the criterion are increased. The persistence of these interferences is also indicated in the number of trials and repeated presentations required to bring I to mastery after the discontinuance of III, indicated after column 42

The performances of Cat C (Figure 3) exhibit characteristics consistent with those of Cat B, such differences as exist being probably in part due to inferior capacities of Cat C. It was not found possible during the period of the experiment to bring this animal to the criterion with concurrent presentations of I, II, and III, although success was attained with concurrent presentation of I and II, a total of 1200 trials being necessary to bring the animal to this point of discrimination. Columns 5, 39, and 40 represent concurrent presentations of I and II Interference effects of the mastery of Habit III on Habits I and II are somewhat more marked and persistent in this animal than in Cat B

In summary it may be noted with respect to the behavior of the three cats tested in these situations

1 Two animals exhibited consistent discrimination in situations in which discrimination was necessarily relevant to at least two varying char-

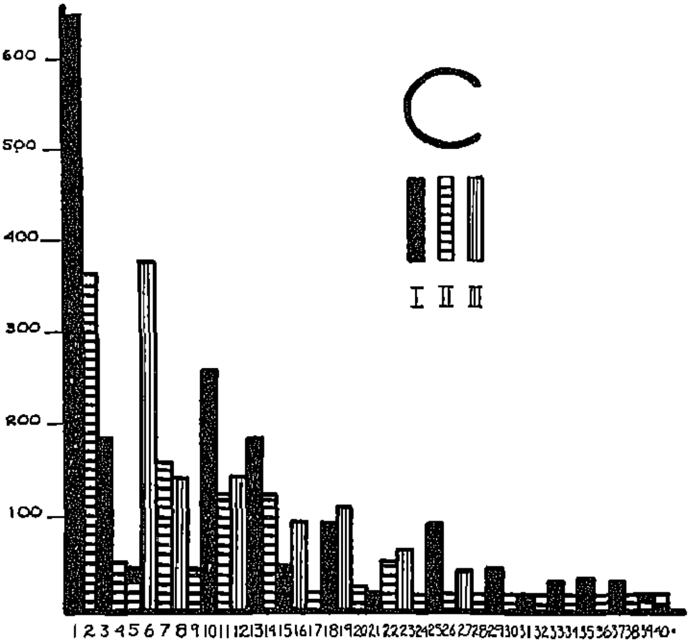

FIGURE 3

acteristics of the stimuli to be discriminated, namely, the size of the squares and their brightness relations with the grounds on which they were displayed

2 One animal reached, and for a short time maintained, discrimination in a situation in which discrimination was relevant to at least three varying characteristics of the stimuli to be discriminated, namely, the size of the squares, their brightness relations with the grounds on which they were displayed, and the nature of the other stimulus with which they were paired

3. Notwithstanding the fact that the animals were able to attain a certain success with the double and triple situations described, the general character of the performances elicited would suggest that the discriminative behavior of the cat with respect to such problems as these is not of a very advanced order The slowness of acquisition by the animals of the double and triple habits as compared with the single habit, the great difficulty of extinguishing interference between Habits I and III, the apparent instability and superficiality of the triple discrimination when it is acquired (it deteriorates easily into position or alternation habits)—these

are facts which indicate limitations in the discriminative capacities of the animals

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THE MUSICAL TALENT OF SOUTHERN NEGROES AS MEASURED WITH THE SEASHORE TESTS

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I INTRODUCTION

Several investigators have used Seashore's tests on negroes, but most of them studied children of this race in public schools of the North Not enough has yet been done to show how far these people can progress with musical training In the South, especially, they show a marked tendency to express themselves in music. They sing while at work or at play, swaying in rhythm with their songs, and seem to derive great enjoyment from this activity. Whether their interest in music is traditional or due to exceptional innate ability is still a debatable question If their music can be developed by training into a really artistic form, it will give them, as well as our own race, even greater pleasure.

Sociological studies have shown that the negroes of the United States are far from pure members of their race, as a rule Crossings with the white race have occurred here and there for over a century, but the most nearly pure blacks are said to be found in greater proportion in the Gulf States, where the writer carried on his experiments The colored people who migrated to the North were, as a rule, the ambitious ones who were capable of more skilled work than was required of them on the plantations in the South. Therefore, studies of these people in the North involve a select group rather than a group typical of the race such as can easily be found in Louisiana

Previous investigators disagree to some extent as to which race is superior in various musical capacities. As space does not permit a complete outline of their results here, the reader is referred to the original sources listed at the end of this article. Some of these experimenters regard the race differences as too small to be reliable Those who studied children in the elementary school seem to agree fairly well that the negroes and whites were about equal in all the capacities tested. As adults, however, the colored subjects made inferior scores except in rhythm, in which they surpassed the whites

There seemed to the writer to be a gap left to fill in. High school pupils had not been tested Therefore, the age of appearance of retardation had not been determined Also, another phase of the general problem was still open to investigation: the study of the musical capacities of a select group of negroes who had elected music as a part of their college course, and the relation of their objective scores on the Seashore Tests to ratings of their ability by their music teachers, and, in a general way, to their accomplishments in the field

II PROCEDURE

The first experiment was carried out in December, 1933 The subjects were 119 juniors and seniors in a negro high school in Baton Rouge, Louisiana The Seashore Tests for Pitch, Intensity, Time, Consonance, and Memory were given. A new electric phonograph with excellent tone quality, well regulated, and in good running condition, was used The room in which the subjects were seated was relatively free from any distortion by echo. Reasonably quiet conditions were maintained

Directions were given as in Seashore's "Manual of Instructions for the Measures of Musical Talent" (11), with the addition of a few introductory remarks to motivate the pupils to put forth the greatest possible effort. Oral practice was conducted for each test before any responses were recorded on the blanks.

The second experiment was conducted in the late spring of 1935 Forty students were selected as subjects, all of whom were studying music in Southern University, a small college for negroes located a few miles from Baton Rouge, Louisiana The school has good standing, considering its size. The selection of subjects from this college avoided a difficulty encountered in the previous experiment, in which many of the pupils were found to be unable to understand and follow directions, and were greatly confused by the strangeness of the test situation The colored school system, which is separate from that for whites, is low in educational standards. In this college, however, all students were able to follow instructions after oral practice, and the newness of the situation did not greatly affect the scores of any subject

The 40 students were all taking private lessons in voice, piano, or some other instrument at the time of this experiment, and were sufficiently advanced to appear in public in ensemble, and in some cases in solo performances Three capable teachers instruct them, two of whom have had exceptional training for members of their race The singing of spirituals by the chorus, quartet, and soloists of this school has been praised highly by numerous musicians in Baton Rouge, and enjoyed by large audiences of white people. Many of these folk songs of the race have been cleverly and artistically arranged by the teachers, and the quartet has made Victor Records of a few of these.

The first step in the procedure was giving the entire group the 1930 edition of the Thurstone Psychological Examination. This intelligence test is reasonably reliable for a short group test. Three weeks later the Seashore tests were given to the same subjects. The conditions were similar to those of the previous experiments. Directions were handled in the same manner as before except that a little more time was allowed for oral practice. In this experiment the Rhythm test was added to those used earlier, and since the total period of work was over an hour in this case, a brief rest was allowed after the third record.

The amount of training received by each student prior to the experiment was tabulated with the scores. Then each of the three teachers ranked his pupils in the group according to ability, that is to say, according to what they could do if they did their best. The following scheme was used: *A*—excellent, *B*—superior, *C*—average, *D*—poor, and *E*—very deficient. These categories correspond to some extent with Stanton's (12) prognostic designations, "safe, probable, possible, doubtful, and discouraged," used in her studies of the capacities of white music students.

The last step in the procedure was a general subjective evaluation of the achievements of the students in music as observed in their ensemble singing and playing, and, in a limited number of cases, in solo performance. Two other musicians added their criticisms to those of the writer in an attempt to judge all important points.

III. RESULTS AND CONCLUSIONS

1. *High School Group.* In the large group of 119 subjects, there were three whose failure to follow directions made their scores meaningless on some of the tests. Such results were thrown out. Besides these, there were several who scored little above chance on nearly all the tests. Some seemed merely to guess the answers and failed to grasp the idea. Such cases were particularly numerous for the Pitch record. Their results were included, however. Only one case of marked superiority on all the tests occurred in this group, and even here the scores averaged in the low nineties.

A table comparing our medians (in percentage right) with medians and means found in three other studies will give an idea of where our results stand.

	Our medians	Gray and Bingham	Johnson		Peterson and Lanier
			College	8th grade	
Pitch	54.5	56.1	75	73	57.93
Intensity	67	69.2	88	82	75.60
Time	69.5	65.7	73	68	70.83
Consonance	64	32.5			63.40
Memory	43.5	21.2	68	54	43.36

Unfortunately not all investigators gave medians Some put down mean scores only, so that the comparison in this table is not exact, but it shows that our scores are lower in general than others for negroes, even though Gray and Bingham (1) and Johnson (3) used some eighth-grade subjects who were younger than ours The few differences in the other direction are too small to be significant. The reader should note that Gray and Bingham gave their results in terms of number of right judgments, making the scores on the last two tests only half of what the percentage right scores would be. Their other means are equal to the percentage right, however

Percentile ranks for our subjects show them to be inferior to whites on all tests, even if eighth-grade norms for whites are used for comparison. The few who had studied music to any appreciable extent did not show marked superiority to the rest, and some who scored relatively high had never had music lessons

2 *College Group* The subjects in the second experiment followed directions correctly They were a select group, of course, and were expected to be better than average for their race, which turned out to be a fact The average extent of their musical training was 2 9 years, not counting some singing by ear done in the high schools None of them were taking music with the aim of becoming professional in the field There were six seniors, 10 juniors, 11 sophomores, and 13 freshmen in the group.

Scores on the different sections of the Thurstone and Thurstone test revealed that over half of the students did a poorer quality of work on the first and last parts than on the three other parts The cause of this lies in the fact that negroes are backward in vocabulary of a literary sort, which is needed in these divisions of the test Probably, therefore, their intelligence scores are a little unfair unless this is taken into account

Scores on the Seashore tests were poorer in Pitch, Intensity, and Time than in Consonance, Memory, and Rhythm Waverings of attention are characteristic of the negro, and distinct lapses of this sort were indicated by rows of successive errors on easy columns of trials on some papers which had more difficult columns filled correctly In this way several scores were lowered that might otherwise have been excellent There seems to be little reason to doubt that a gestalt of such a nature as the melodies and rhythms of the last two records holds attention better than two simple tones differing in pitch or loudness Most intelligent adult whites can attend to a task over a long period in spite of its monotony, but this is not true of negroes, who in most cases were not trained well in voluntary attention in early years at home or in school

The mean percentage right figures were Pitch 72 15, Intensity 82.5, Time 77.2, Consonance 73 9, Memory 77, Rhythm 83 8. We note that our means are in every case above the medians for negro college students found by Peterson and Lanier (8), and in every test except Intensity above their medians for whites of college age. Many individuals showed marked excellence in Rhythm. Though a few scored very high on four or five of the tests, no one excelled throughout. Most of them had a percentile rank of below 50 in intelligence (using norms for white college students to determine their rank), but they were probably superior negroes as a group. None were too dull to understand the task. The mean percentile ranks were Intelligence 27.2, Pitch 28.4, Intensity 27.9, Time 49.2, Consonance 69, Memory 58.4, Rhythm 85.5.

The teachers did not rate any student lower than *C* in ability. There were 18 *A*'s, 21 *B*'s, and only one *C*, or average, student.

Mean percentile ranks for these groups were

	Pitch	Intensity	Time	Consonance	Memory	Rhythm
A	37.5	36	56.6	69.4	68	86.8
B	21.7	20.9	45.6	68	50.9	84.4
C	10	0	35	85	30	85

The one *C* individual excelled the mean of the *B* group in Consonance, about equaled them in Rhythm, but was inferior on the whole. The *A*'s surpassed the *B*'s definitely except in Consonance and Rhythm, in which they were about equal. Correlations of the various capacities with intelligence were low, but in every case sufficient to indicate a relationship to some extent. The coefficients were Pitch .20, Intensity .35, Time .36, Consonance .29, Memory .29, Rhythm .26.

Observations of negro musical performance indicate that deficient sense of pitch is common among these people. They glide from one tone to another in singing, and hold to no rigid pitch restrictions, rising and falling again on one tone at times. Their ensemble singing and playing is rhythmically precise and well synchronized, even in the most intricate rhythmic patterns. Strong accents and glides make the music of their own race effective, but their rendition of the classics is often spoiled by inaccuracies of pitch, and by an attempt to carry over their own style into a kind of music requiring careful, well disciplined interpretation.

No case has been found by the writer of a negro who had a marked degree of capacity in Pitch or Intensity. Many showed a percentile rank above 95 in Rhythm, and several had decidedly superior ability in Tonal Memory.

In conclusion we may say that this race is definitely inferior to our own in musical capacities, with the probable exception of Rhythm, in which they are at least equal if not superior to white people. As far as data can be obtained at present, negroes appear to score about as well as whites on Seashore's tests while they are children, but at adolescence the negroes fall behind while the whites go on developing musically the same as they do in general mental capacity The teachers can roughly rank their own pupils in ability, and make use of all the elements included in Seashore's tests, in their judgments, according to results given here, but their standards are low. Tests show the educational possibilities of the black race to be limited in this field.

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LEARNING AS A FUNCTION OF THE SPATIAL INTERVAL BETWEEN DISCRIMINANDA

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1 *To what extent is the rate of discrimination dependent upon the distance between the items to be distinguished?* The decisive rôle played by purely external physical factors in governing the rate of learning has long been recognized by experimental psychologists of all schools of thought The effect of relative size, unique shape, and impressive color in facilitat-

ing adaptation to stimulus-objects is likewise appreciated by every layman In the practical field of reading, we all know that the amount of white space separating letters, words, and lines is an important element in determining the speed and efficiency of this form of visual reception.

This study is concerned with an analogous situation in the behavior of the white rat. His capacity for visual discrimination has been studied in a thousand different ways, but few investigators have raised specifically the question What influence does the gap between the objects to be discriminated have upon the course of learning? What distance between a paired set of discriminanda (to use Tolman's recent term) is most conducive to a mastery of the problem? Is sign-learning directed toward the different meanings or values of a plain black and a plain white square card dependent upon the interval between them?

2. *Training and testing the animals.* The answer was sought by means of a duplicate of the original Lashley jumping apparatus used in measuring the rat's visual performance. This contrivance is a simple grey upright wooden screen, about 5 ft high and 3 ft wide Two 5½-in square holes are cut into the frame at the standing chest height of the experimenter, at the rear of the openings a 12-in shelf is attached The apertures are closed with 6-in squares of heavy cardboard held in place against the back of the screen by inserting their lower edges in a shallow groove cut in the back food platform and fixing the top either by a rigid turn button or by a light spring.

Training is accomplished by placing a stand with a circular top near the screen and allowing the rats to step through the open holes to the platform, then gradually withdrawing the stand until, in about 30 trials or so, the standard distance of 25 cm. is reached Black and white cards are then placed in position and training in discrimination begun During the instruction series, one card bearing the negative stimulus (which may be either black or white, depending upon the animal chosen) is fixed rigidly, the other is held by the spring so that when the rat jumps against it, the card drops back and permits him to reach the food shelf If he hurls himself against the wrong entrance, he falls down a sheer cliff-like wall into a net near the floor.

The present inquiry grew out of the fact that in Lashley's original apparatus the openings are spaced two inches apart Why just two inches? Why not one inch or one foot? Wertheimer and others have shown that nearness is one of the factors (along with likeness and other qualities) making for the formation of a dynamically distinct gestalt If the discriminanda are close together, are they hard to split apart or are they relatively easy to distinguish compared with greater intervals? When we match shades or compare twins we find it necessary to get them fairly close to each other, since a better "gradient" appears to be established thereby, but is it possible to get them too near for good results? The dynamics of the act of comparison (whether successive or simultaneous) assumes that the effective gradient is a resultant both of the difference of "potential" between the two stimulus-areas *and* of the spatial distance separating them.

Four different intervals between the edges of the cards were selected, viz, 15, 30, 45, and 60 cm At each distance, two rats (only females were used in this experiment) were taught to jump toward the black, and a similar pair toward the white. The criterion of learning was the ability to make ten consecutive correct choices, and the measure of relative difficulty was the average total number of preliminary jumps required to attain this level It should be mentioned that a long rectangular jumping shelf-type stand was now substituted for the original circular top, the change being necessitated by the mechanical difficulty of leaping at a sharp angle. In all the critical tests, the animal was placed at the exact center of the jumping stand with head oriented toward the middle of the discrimination screen This permitted the animal to run back and forth on the ledge until he was ready with his choice, in which case he would invariably leap at right angles toward the objective

3. *The presence of an optimal interval and its explanation.* With due regard to the obvious limitations of this experiment, it appears that there is an optimum interval of about 45 cm which is most conducive to rapid and effective learning of simple brightness discrimination. The mean number of jumps required to reach the criterion stage, where black was the positive stimulus, was 119 trials at 15 cm, 124 at 30 cm, only 69 at 45 cm, and a sharp rise to 182 at 60 cm Where the white card was positive the figures follow essentially the same pattern, being 170 at 15 cm, 99 at 30 cm, 67 at 45 cm, and 194 at 60 cm It is approximately twice as easy to evoke adequate discriminatory responses to a physically "simple" pattern as to others fundamentally like it except that the gradient of difference is less sharp A careful inspection of the accompanying figure reveals a gratifying consistency of response, note particularly the surprisingly small scatter around the 45-cm and the 60-cm points.

Assuming the technical correctness of these findings, is there any explanation to account for them? It was thought at first that the usual mammalian lateral placement of the two eyes makes it easier for a rat's visual mechanism to operate at an angle than if he had the full frontal-parallel binocular vision of the human. However, this interpretation is not very convincing or even applicable to this situation since the animal typically paces up and down, inspecting the stimulus-objects, and oscillating for a longer or shorter period before making the jump Such behavior seems to exclude any explanation in terms of mere optical or even retinal peculiarities

A somewhat more plausible account, emphasizing central rather than peripheral factors, may be found in the figure-ground approach to the

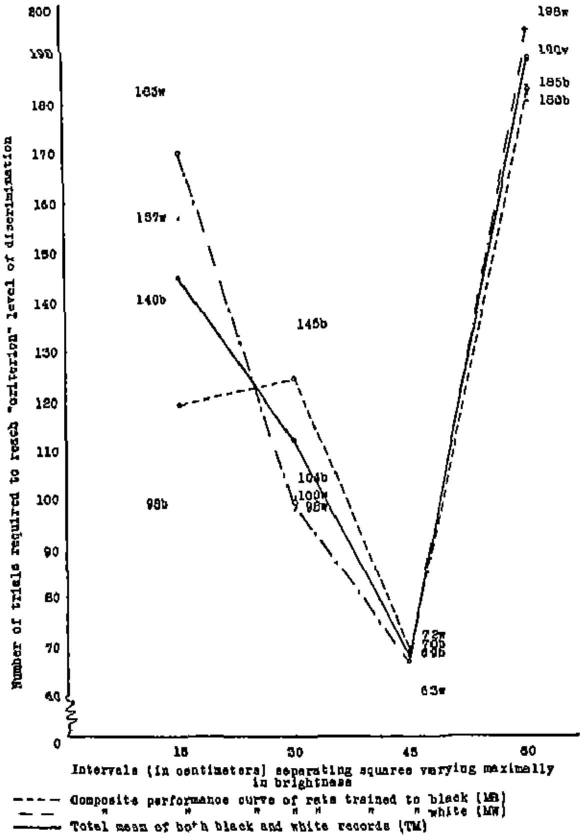

FIGURE 1

Number of jumps required by 16 female rats before they learned to distinguish black and white squares placed at different distances apart Four different animals were used at each interval The solid black dots indicate the records of each individual rat

problem of perception According to this view, maximum differentiation of the discriminanda occurs when the figures are most sharply set off from each other and from their common background. Place the figures too near together and they become assimilated into one common field, put them too far apart and the anticipated configuration is destroyed, or at least made harder to reconstruct. A human parallel to these rats' behavior may be found in the extremely contrasting effects produced by a badly printed page without leading or the continuous and unbroken lettering of mediaeval manuscripts, which are hard for a modern to decipher, and the reverse situation obtained were we to print but one letter each of a long word on a series of single pages The rate of learning is adversely affected in both instances and points plainly enough to the existence of a *general law of behavior stating that there is an optimum spatial interval between all visual items to be discriminated.*

This conclusion is a partial confirmation of Jacobs' (1) finding with dark-adapted human subjects that maximum sensitively, i e, the lowest thresholds for brightness differences, occurred at an 80-cm interval rather than at a 10 cm or 200 cm She claims, however, that her initial procedure left the varying retinal sensitivity of fovea and periphery uncontrolled, and that when constant "local" projection was assured, the threshold rose steadily with the distance In photometric practice it has long been known that the threshold is lower when the comparison fields lie as close together as possible, and that it is lowest of all when they are in contact without any line of separation

Under "pure" conditions it seems reasonable to expect such a linear function, but, the natural conditions of motility permitted, our animals yielded a curve of wholly different shape It is doubtful if this difference can be attributed to the divergent properties of mice and men. Koffka (2, pp. 480-481), commenting critically on Jacobs' work, and referring to some unpublished studies of Mintz, says. "The minimum of the difference threshold does not lie at the smallest spatial distance, instead when one decreases the spatial distance continually, a minimum of the difference threshold is reached, such that with a further decrease of this distance the threshold begins again to rise If the two objects to be compared are too near each other and sufficiently similar, then they will become assimilated to each other, proximity appearing again in its rôle as a unifying factor" This explanation is similar in spirit to the qualitative one outlined by ourselves above, and may be considered as of more general applicability than the special case developed by Jacobs

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FORM AS A PRINCIPLE IN THE PLAY OF CHILDREN

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When one watches children at play, one soon observes that there are certain principles that appear again and again In a previous study by Bender it has been pointed out that motility is a factor in determining the form of children's drawings and games Children often take toys such as carts, trains, etc, and move them on the ground with outstretched arm in a curve or in a half-circle, the center of which is the shoulder joint The plane on which the play takes place is seemingly one factor, the peculiarities of the motor apparatus is another factor Kluver has observed drawings in monkeys which are determined by similar principles In hop scotch, the figure in which the play takes place is determined by the range of jumping on one leg, the curved form is drawn with outstretched arms with the body as a pivot. Rotation around a longitudinal axis is one of the basic forms of movements Kohler describes whirling as a form of play in apes The principle of rotation is also demonstrated in the movements of the circular joints such as the shoulder and hip and in some degree also in the hand In the parietal lobe lesions with spontaneous turning around the longitudinal axis, Hoff and Schilder have observed also a tendency for rotation in movements in the circular joints.

Specific motor tendencies, therefore, find an expression in the play of children The motility adapts itself to the plane on which the play takes place The formation of foreground and background is basic for the play of children When a child gets a number of lead soldiers or other toys for play, the form of its play is partially determined by the form of the field in which the play takes place The 3½-year-old Joey puts soldiers near to the border on the table and also on the bench He transfers them also to the border of the wash basin He puts a horse in the middle of a small desk calendar He presses the head of the horse against the cork of a closed ink bottle as if trying to push it in and says, "I push him in this" He even attempts to put the soldiers parallel to the wall and is disappointed when they do not stay in this position The geometrical and physical qualities of a given field are determining factors in the play of children The instance with the ink bottle shows that the form of the objects is another determining factor. It becomes a symbol into which one can push something else We will consider again the more primitive geometrical forms. This child likes clusters of three men around a horse He arranges soldiers in a row. He puts a soldier in each of three corners of the wash basin He arranges soldiers and tongue depressors in forms of incomplete symmetry The following primitive forms emerge (1) a cluster; (2) a row, (3) an irregular star

The observation of this child attempting to place the toys against the wall makes it clear that experiments with the gravitational qualities are factors which have to be considered in the play of children. This child does not take gravity into consideration at first. In the play of Nora (four years old) and Rita (three years old) pushing objects over or allowing them to fall was a great source of pleasure. These are instances of active experimentation with gravity.

There is no question that the play of these children has also another meaning. Joey is continually commanding the toys which he puts in specific places. In the play of the two little girls, their delight in power and aggressiveness was obvious. The formal elements are, of course, not isolated parts in psychic life but are a part of the biological orientation of children. Knocking toys down satisfies the aggressive impulses of the children but it also helps to a better handling of problems of physics connected with gravitation. To be upright or to lie down is partially a moral problem (aggression and submission) but it is also a problem in physics and of the orientation of the organism concerning gravity and the physical world. Orientation means for us not only perception and knowledge but also the motor side of the adaptation of the individual.

Larry (four years old) and Russell (five years old) showed a great interest in replacing into an upright position the dolls that had fallen down. Whenever the examiner pushed the doll down, Russell would stand it up again. Immediately after this play, Larry noticed a man cleaning the windows and said, "He will fall down."

In the later development there is a tendency for clusters to develop into more symmetrical forms. The matching of objects plays a great part. Objects which are similar in shape and colors are put into groups. This was shown, for instance, in Vivian who is nine years old. Her play with china toys consists entirely in arranging them in different symmetrical forms on the table and moving them from one form to the next, sometimes transporting them by means of tiny carts.

We have mentioned that the 3½-year-old boy showed a tendency to push the horse into the ink bottle. In older children, this tendency to put something into something else is still more obvious. The children put lead soldiers into carts, either lying or standing, and they try to pile in as many soldiers as possible, sometimes pushing the soldiers in rather roughly. It is a great satisfaction for them to have as many in the car as possible. If there are bigger and smaller cars, the smaller cars are put into the larger cars as well. Five-year-old Emmanuel, for instance, puts one car into the other and said he would put them into the garage. The same principle prevails in older children as is seen from the protocol of Charles, an 11-year-old boy of average intelligence.

> They had a war—the Americans and Indians. I am on the side of the Americans because that is my nationality. (*What is the matter with the Indians?*) They can't fight so good. I am only playing with them. Here is the battlefield (puts all

> the soldiers in carts and puts them in another position) Bang-Bang That guy is dead. (The Americans kill four Indians. One Indian knocks down an American) They are having a war because they don't like Indians (he put the small racer in the big truck) That is the place where you carry things, because they can't carry them in their hands; they are too big (He lines all the vehicles up and lines the soldiers up along the edge of the table) I am going to line some over here too

In a later course of the play he places vehicles in a series whereas they were parallel before He likes to give orders to his lead soldiers. He always arranges the soldiers in groups

This protocol shows an elaboration of the same form principle which we found in the younger children The elaboration partially consists in adding meaning to the formal situation This tendency is already present in the younger children They put a soldier, for instance, in a car "because he is dead" or "tired" or "he has gone home" One gets the impression that the formal principle of putting something in something is more basic and is merely exemplified in the meaning added.

Children are never satisfied with any form which is reached One form is merely a transition to a chaos, that is putting the toys in an unorganized heap But new organization is immediately sought again. In older children, the groups have a more definite meaning, Indians, soldiers, pirates, etc In younger children, however, grouping as such is the main purpose. Although the same principles are returning again into every new grouping, the new grouping is never completely identical with the previous one Whereas in the protocol of the 3½-year-old boy, tongue depressors and soldiers are brought into a symmetrical form without further comment, older children usually give some definite meaning to their groupings. It is as if they would have adapted the formal principles better to the total situation and its meaning. In this respect it is particularly interesting to follow the development of a situation which we have called the automobile test A man is put between three cars which are so placed that the front ends are all pointing towards the man. In the younger children the man and cars are pushed about without much regard for the inner quality and meaning of the objects Children start to move the car or, at any rate, to imagine a movement which corresponds to the structure and position of the car. In such an experiment where James (seven years) and Dorothy (nine years) are present, the girl starts running the car, the boy runs the man down with the car and puts him into another car. (*What did you do?*) "I knocked him down, he was run over, the guy was carrying him" (*Why did you stand him up again?*) "He will be run over again," said Dorothy "The car will run over him and he will be dead" In the midst of a discussion about death, Dorothy kisses the smaller car and says, "Because it is little" She puts it in another car and says, "I don't want it to get knocked over." The car with its momentum needs to be played with according to its structure It carries with it an immediate pattern for aggressiveness but only older children are able to grasp this situation The younger ones express aggression by merely knocking over Of course, a complicated object like a car does not merely carry the meaning of aggression in it but it is also, as mentioned before, a vessel and a container The definite meaning of an object depends, of course, on the total situation

The following protocol exemplifies what we have said. Five-year-old *Emmanuel is shown a cowboy between two cars He said*

> It bumps him He better watch out—because—he is dead (He knocks down the car) Fall down car (Several other cars are now put at his disposal and he piles up the cars.) *I am making something Put this one on top because it fell* down. Goes slow because it is broke (He lines up the little cars against the wall.) It will crack (Knocks a big car against a little one) Now it cracks (Piles them up again) Now I make a car. (He puts a little car in a big one) It is broke . . I tell you so many times It broke itself I say All the cars broke Put it in the garage and get it fixed I bring it back (Gets men and puts them in the larger car) They are garage men to fix the car. (The next day he gets a set of lead soldiers with carts and wooden toys representing the various members of a circus He puts all the toys in the largest cart including smaller carts He looks all over the floor for more toys) This is the march (He lines all of the circus toys on one side and the lead soldiers on the other side and knocks over the circus toys and then the lead toys) They knock down, they go to sleep I fix them all over. (He puts all the lead toys and the circus toys in the cart again He puts small autos, soldiers, elephants, etc., all in the larger cart Then he knocks them all out again.) They are dead, they got run over

In a little older age group the consideration for the actual meaning of the toys is greater. Amad is nine years old and Leon is seven Following are some protocols

> Leon: (two cars and man) The car is going to run the good guy over He will die.
>
> *Amad He don't die He will get hurt and they bring* him to the hospital and he will get better and when he sees that truck again he gets that man and kills him
>
> Leon The man is going to break the car up and burn the man in the car so it won't run over him no more (*How can he if he is dead?*) The car got electric and burns him up. The car could fall. The feet must go on the electric and then the car could fall. This car was coming and he is strong, and he went back that way, then that car comes and he doesn't see *it and he gets hurt and they bring him to the hospital* He gets better, sees the truck, burns it up, puts it on fire and brings it in the river, makes the motor go

> Amad He puts dynamite under it, then ran away
> Leon The car is coming and the man is going across and the car got the man run over, and the man got hurt The car went right on the man's foot and the man got a broken foot. They bring him to the hospital They gave him a stick and a foot to walk When he sees the car he is going to take the wheels off and the motor off and put it on his car, and break that car and throw it in the river
>
> Irregular arrangement of several figures with small cars
> Leon. (immediately) This is a good guy—this is a bad guy—this guy is going to kill this guy with a knife, so that he comes with all the guns and he is going to shoot that guy, etc
>
> The play becomes increasingly violent and many more of the lead soldiers are considered as dead and piled into the car.

The purely formal elements are decidedly subordinated and integrated to the mental content. Only when the play progresses do the more primitive form elements come more and more into the foreground The play satisfies those instinctual tendencies of the children which correspond to the form of the play. In the instances taken the aggressiveness of the children is able to express itself in the play.

We have not mentioned that it is characteristic for children never to be satisfied with any less than all of the playthings which are available They want to get everything that there is to be had, otherwise they feel restless and dissatisfied. The child is only temporarily satisfied when he has gotten everything that is in the room They often ask where the toys came from and whether one could not buy all the toys in the store The following protocol is very characteristic. Russell (five years old) is an aggressive over-active child of inferior intelligence (IQ 71) and Larry (four years old) is usually shy and quiet on the wards but has a history of temper tantrums at home

> The examiner knocks a doll over
>
> Larry Take another one
>
> Russell: Me take another one
> Larry: Look at the two here
> Russell: Me throw it down Stand it up One doll, two dolls Stand up one doll.
>
> When the dolls fall down very easily, the chief interest of the children is to get it into an upright position Whenever the examiner pushes the doll down, Russell stands it up again. Takes it into his hand Russell is rather petulant Larry takes the dolls in his hand in a protective way He picks up the lead soldiers and looks at them very carefully. Russell wants everything immediately He insists on it
>
> Russell Give me all the mans.

When the toys are taken out of the drawer he does not want to play with the toys which are given him but tries to take other toys out of the examiner's pocket Larry does not show any constructive effort in play He merely takes everything in a rather protective manner to himself and only lets a car run slowly over the desk He does not let the cars collide.

Russell has seemingly forgotten that he wanted dolls from the examiner's pocket but is easily reminded of it. Puts his hand in the examiner's pocket and says, "No more, only matches." He appears to be disappointed.

Larry asks for the horse "Let's see the horse" Russell immediately loses interest in what he has Russell has a definite reaction pattern in that he wants everything and once he has it he is not interested in it any more

Russell The bad boy won't give me the cars

Russell is somewhat dominated by the idea that something is withheld from him In order to get the cars, he takes two pieces of paper and gives it to Larry When Larry finally gives him the things, he has no interest in what he has asked for Russell offers Larry the broken legs of a doll The interest of getting something he shouldn't get, makes any active play for him completely impossible

It is interesting to notice that he wants to get the last thing that the other boy has When something is given to Larry, Russell immediately becomes excited Finally, he gives Larry the broken legs of the doll again with a great gesture of generosity.

Larry could be induced to give the other boy everything.

In play, Larry seems to put the lead soldiers together without putting them in any action He rather carefully avoids pushing any one of the figures down He does not protest *when one toy after another is taken away. He takes two trucks* and when given a doll which is named Doris (his sister) he makes a noise with his mouth, plays with the later car *and tries to put the doll into the car*

The child is a little shy and does not even dare to take off the hat of the doll When the examiner pushes the doll *down, he heaps the two cars upon her abdomen* and her face and he continues to play, covering the dolls with the cars Finally he brings the car near the doll which is now standing but does not push her down. He brings it as near as he can The examiner pushes the doll down with the car and he repeats it He lets the doll fall down rather carefully. When he plays, he is very careful not to come too near the doll He frequently covers the doll up with the cars

He sees a man cleaning windows and says, "He will fall down" This is a child who restricts himself in the movements to small and rhythmic expressions He is not very active in play After child left the room, he had a severe temper tantrum and had to be placed in his room by the nurse Later he became quiet and on being sought out, it was found that he had defecated in the room and smeared the feces over himself and the room.

One sees that the emotional problems and the formal problems cannot be separated completely The experimentations of the child with form and configuration is an expression of its tendencies to come to a better handling of objects by action. By trial and error it comes to an insight of the structure of objects. To the structure of the object belong the general spatial qualities, the laws of gravitation, push, and momentum The child has to learn about lines, series, and groups Furthermore, it learns about the general form when something can be put into something else It is remarkable that the same gestalt rules have been worked out by one of us in connection with spontaneous drawings of children and concerning the general gestalt principles in visual motor patterns These problems lead to emotional problems, problems of destruction, preservation and protection. We are of the opinion that the emotional problems and the so-called form problems are identical in their core. One could, for instance, consider the problems of impact and putting one thing into another as specifically sexual problems as, for instance, Melanie Klein has done who sees in every collision in the play of children a symbolic hint to the parental intercourse If one puts merely the emphasis on the sexual interpretation, one neglects biological connections which are at least as important as the sexual. One could with some right consider the interest of the child concerning parental intercourse as an application of its general interest in impact and putting one thing inside of the other In the children of our group in which the play method of approach could be used (under ten years) there was no difference between boys and girls The individual fate of the single child determines very often formal principles specifically used. In one of our children the motive of attacking from behind was outstanding In some children the impact problem plays a greater part and in others the tendency of putting things into other things In other words, there is a general trend of psychophysiological organization which is not rigid but more or less a mode of procedure adaptable to the biological situation. Form principles reflect merely the general plan of psychophysiological organization

SUMMARY

The form of the organism and its motor possibilities determine the play of children Rotation of the total body around its longitudinal axis and circular movements of outstretched limbs are of special importance The motility adapts itself to the plane on which the play takes place The play starts with the formation of foreground and background The child undertakes a continuous experimentation concerning the geometrical qualities of lines, angles, and clusters In the three-dimensonal game, the child is particularly interested in whether something can be put into something else Further experimentation concerns gravitation, push, pull, and momentum. The experimentation with space and mass (geometry and physics) is based

upon the instinctive drives of children and, therefore, dependent upon their individual emotional problems. The definite form of the play is adaptable to the biological situation. Form principles reflect merely the general plan of psychophysiological organization

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THE EFFECTS OF TRAINING UPON INDIVIDUAL DIFFERENCES

SERIES I

E B SKAGGS

I. INTRODUCTION

The data presented in this paper are data which emerged out of investigations which were not planned primarily to test the effects of practice on individual differences. However, regardless of this fact, the data presented are essentially valid in showing the relationship between training and changes in individual differences

Much has already been done on the problem, but much more remains to be done It is especially important now to note the part played by various factors which may enter in to determine whether practice shall reduce, increase, or leave unchanged the individual differences of any group Above all, there is much need for investigation in which the subjects are trained to their ultimate limit of improvability and where they are motivated very strongly

Eight separate studies involving eight different groups of subjects (hereinafter designated as *S*'s) are reported in this paper. All *S*'s were either college sophomore men or women, ranging in age from 18 to 20 years. Five of the groups were men and three were women Every group consisted of 20 *S*'s with the exception of Groups VII and VIII which consisted of 19 and 18 *S*'s respectively This made, in all, 157 subjects

The task consisted in replacing the blocks of a Goddard formboard from a second formboard which held them in a constant position at the beginning of every trial Since a description of the arrangement of the boards and the manner of working them has been reported in detail in a previous paper (2), only a very brief statement will be made here The *S* used both hands at a time, picking up and replacing, according to a set order, two blocks at a time At the beginning of every trial the experimenter (hereinafter designated as *E*) stood in front of the *S* and before the formboard which was to receive the blocks *E*'s body was thus a screen to hide the boards and blocks from *S* *E* then said, "Get ready One, two, go!" As *E* said "Get ready," he prepared to step to the right and aside. As he said "One, two" he stepped to the right As *E* stepped aside, *S* stepped up in position before the table and the boards, bent over, placed the fingers just over, but not touching, the first two blocks and, at the signal "Go," began to replace the ten blocks as rapidly as possible *E* started his stopwatch as he said "Go" and stopped it as the last block was replaced

No *S* knew the nature of the experiment He was told that we wished to make a study of learning curves and that he was to do his best, to become just as much of an expert as he could in the time allotted for practice He was told his score after every trial, and his scores were kept by himself day by day so that he could watch his own progress The *S*'s talked together about their work and compared scores within their own smaller group of co-workers At every meeting *E* gave this admonition to *S*: "Remember that today you are going to do your very best You are going to step up and make the best record you can at every trial." *E* never indulged in faultfinding or criticism when *S* made a poor record but, rather, made a few encouraging remarks All in all, while our *S*'s might have been motivated more highly, they seemed to have worked with good spirit and zest throughout

The writer served as *E* in Studies I to V, inclusive, while Miss Dorothy Ransom served as *E* in Studies VI to VIII, inclusive Miss Ransom was trained by the writer until her technique was closely similar to that of the writer in giving the tests Every *S* was met individually by *E*. The apparatus (formboards and blocks) was in a laboratory darkroom and was illuminated by a constant artificial light Every *S* came to the experiment room at the same time each day

Reed (1) and others have indicated that the method of calculating the effects of practice upon individual differences is very important Following Reed's suggestions regarding the relative reliability of the various methods used and relying upon his own ideas of the common-sense significance of the methods, the writer finally decided to use the following three methods of calculating the effects of practice. These have been designated as Criteria A, B, and C

Criterion A consists of a comparison of the range of initial and final ability-scores Criterion B consists of finding $\frac{S\,D}{M}$ and expressing it in percentage terms According to Criterion C we first found the average score for the best and for the poorest one-fourth of our *S*'s at both the beginning and at the end of the training period Since these are all well-known methods or criteria no more will be said about them at this point

II RESULTS OF EIGHT STUDIES ON EFFECTS OF PRACTICE, UNDER DIFFERENT EXPERIMENTAL CONDITIONS

In this section we shall present the results of the eight studies made under different experimental conditions of sex, length of rest-pause between trials, and amount of distribution of effort

Study I Group A The *S*'s in this group consisted of 20 men A rest-pause of 60 seconds occurred between every trial at a given meeting The first meeting occurred on a Friday. Then *E* demonstrated to *S* the manner of working the board *S* then worked the board two times slowly and carefully without being timed Ten trials were then timed and the average of these ten trials was taken as the index of *S*'s initial formboard ability[1] Then, on the following Monday and every day thereafter for five days, *S* worked the board 20 times at every meeting This made a total of 110 trials The average of the final ten trials was taken as the index of final formboard ability

The following results were found by applying the three methods of calculating effects of practice.

Criterion A First 10 trials: range 7 14 to 4 82, difference, 2 32
Final 10 trials range 4 42 to 3 47; difference, 0.95.
Result training has reduced range 1.37 units
Criterion B First 10 trials, 0 68 is 11 35% of 5 99
Final 10 trials 0 29 is 7 38% of 3 93
Result training has reduced $\frac{S.D}{M}$ by 3 97.

Criterion C:
First 10 trials: poorest ¼, 6 82, best ¼, 5 20, difference, 1 62
Final 10 trials. poorest ¼, 4 31, best ¼, 3.59, difference, 0 72
Result training has reduced differences 0 90 units

Study II Group B The S's involved in this group were also 20 men and the conditions of the experiment were exactly as those in Study II except that a rest-pause of 30 seconds was taken between trials on any given day. The results, by the three criteria of judgment, are given below

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[1] *It may be objected that we should have used the first five, the first 20,* or other groupings, and the last five, 20, or some other number We have made computations using these larger and smaller groupings and it has made no difference in the above reports Hence, the results have not been reported in this paper

Criterion A First ten trials range 7.22 to 4.67, difference, 2.55.
Final ten trials: range 4.72 to 2.93, difference, 1.79.
Result training has reduced range 0.76 units
Criterion B. First 10 trials. 0.69 is 12.06% of 5.72.
Final 10 trials 0.45 is 11.93% of 3.77.
Result, training has reduced $\frac{S.D}{M}$ by 0.13.

Criterion C
First 10 trials poorest ¼, 6.70; best ¼, 4.95; difference, 1.75
Final 10 trials poorest ¼, 4.34; best ¼, 3.23; difference, 1.11
Result, training has reduced differences 0.64 units

Study III. Group C The *S*'s in this group consisted of 20 college women Otherwise the conditions were as those reported for Study II The results follow.

Criterion A. First 10 trials. range 8.56 to 4.96; difference, 3.60
Final 10 trials: range 4.73 to 2.96, difference, 1.77.
Result training has reduced range 1.83 units.
Criterion B First 10 trials 0.89 is 14.73% of 6.04
Final 10 trials: 0.40 is 10.58% of 3.78
Result, training has reduced $\frac{S.D.}{M}$ by 4.15.

Criterion C:
First 10 trials. poorest ¼, 6.95, best ¼, 5.13; difference, 1.82.
Final 10 trials poorest ¼, 4.30; best ¼, 3.22; difference, 1.08.
Result, training has reduced differences 0.74 units.

Study IV Group D The *S*'s in this group were 20 college women. The experimental conditions were the same as in Study III with the exception that ten trials were taken every day, after the initial meeting, for ten successive days. As in Study III there were, in all, a total of 110 practice trials The outcome of this study is given below.

Criterion A: First 10 trials range 6.70 to 4.63, difference, 2.07
Final 10 trials, range 4.51 to 3.44, difference, 1.07.
Result: training has reduced range 1.00 units
Criterion B: First 10 trials: 0.54 is 9.15% of 5.90.
Final 10 trials: 0.25 is 6.30% of 3.98
Result: training has reduced $\frac{S.D.}{M}$ by 2.85.

Criterion C:
First 10 trials, poorest ¼, 6.55, best ¼, 5.17, difference, 1.38
Final 10 trials: poorest ¼, 4.37; best ¼, 3.63, difference, 0.74.
Result training has reduced differences 0.64 units.

Study V. Group E *S*'s in this group were also all college women, 20 in number The experimental conditions were the same as in Study III except that, following the initial meeting, the *S*'s worked the board five trials every day for 20 days The results of this study follow

Criterion A First 10 trials, range 7.96 to 4.96, difference, 3.00.
Final 10 trials range 5.08 to 3.33; difference, 1.75
Result, training has reduced range 1.25 units
Criterion B First 10 trials 0.83 is 13.63% of 6.09
Final 10 trials 0.46 is 11.44% of 4.02
Result training has reduced $\frac{\text{S.D.}}{\text{M}}$ by 2.19
Criterion C,
First 10 trials: poorest ¼, 7.15, best ¼, 5.13, difference, 2.02
Final 10 trials: poorest ¼, 4.30, best ¼, 3.32, difference, 0.98
Result, training has reduced differences 1.04 units.

Study VI Group F There were 20 *S*'s, all men, in this group This study is a counterpart of Study III, the conditions being the same, with the following exception After having done 110 practice trials, every *S* came back on the following Monday and took a final test of 10 trials This made a total of 120 trials, instead of 110, as was the case in Study III The results are presented below.

Criterion A First 10 trials range 7.00 to 4.50, difference, 2.50.
Final 10 trials range 4.38 to 2.98, difference, 1.40
Result, training has reduced range 1.10 units.
Criterion B First 10 trials 0.59 is 10.61% of 5.56
Final 10 trials: 0.34 is 9.29 % of 3.66.
Result training has reduced $\frac{\text{S.D.}}{\text{M}}$ by 1.32.
Criterion C:
First 10 trials poorest ¼, 6.47, best ¼, 4.85; difference, 1.62
Final 10 trials, poorest ¼, 4.14; best ¼, 3.20; difference, 0.94.
Result: training has reduced differences 0.68 units

Study VII Group G This group consisted of 19 men *S*'s The conditions were the same as in Study IV with the exception of the ten added final test trials as mentioned just above This study may be regarded as the counterpart of Study IV The findings are reported below.

Criterion A First 10 trials range 6.33 to 3.77; difference, 2.56
Final 10 trials range 4.27 to 3.23, difference, 1.04.
Result training has reduced range 1.52 units
Criterion B First 10 trials 0.59 is 11.54% of 5.11
Final 10 trials 0.28 is 7.80% of 3.59
Result training has reduced $\frac{\text{S.D.}}{\text{M}}$ by 3.74
Criterion C:
First 10 trials: poorest ¼, 5.84; best ¼, 4.43; difference, 1.41.
Final 10 trials poorest ¼, 3.96, best ¼, 3.27, difference, 0.69
Result training has reduced differences 0.72 units.

Study VIII. Group H This group consisted of 18 college men and the experimental conditions were the same as those in Study V with the exception of the added ten final trials as noted in Study VI. Hence, this study is a counterpart of Study VI. The results follow

Criterion A First 10 trials range 6.71 to 4.01, difference, 2.70
Final 10 trials range 4.29 to 3.00, difference, 1.29
Result training has reduced range 1.41 units.
Criterion B First 10 trials 0.65 is 12.62% of 5.15
Final 10 trials 0.36 is 10.28% of 3.50
Result. training has reduced $\frac{\text{S D}}{\text{M}}$ by 2.34.

Criterion C.
First 10 trials poorest ¼, 6.04, best ¼, 4.44, difference, 1.60
Final 10 trials poorest ¼, 3.98, best ¼, 3.13, difference, 0.85.
Result training has reduced differences 0.75.

The data which have been presented indicate that systematic training has made the individuals more alike in our various groups.

III. CONCLUSION

Regardless of the criterion used, and regardless of differences of sex, length of rest-pause, or form of distribution of practice, the results of eight studies show that individual differences in our groups have been *reduced* by systematic training or practice. Our data do not answer the question of what would have been the ultimate result if every subject had been trained to his absolute physiological limit in the task involved.

IV. DISCUSSION OF CONCLUSION

The above conclusion is valid only in case the ability-time relationships which are used are valid. Since there is something of an inverse relationship, linear or curvelinear, between ability and time, it may well be contended that we should have used the reciprocals of every time-value instead of working with such indirect relationships. As time-value increases, it signifies a lesser ability and vice versa. If the reciprocals of the time-values are used, one will arrive at an almost diametrically opposite conclusion, the data will indicate that training has *increased* individual differences.

It is possible that neither the method of converting our figures into their reciprocals nor using them in the rather simple and direct way that we have done is justifiable. Unfortunately, we do not know where the zero point is located in our time-ability scale. Certainly our *S*'s did not start at zero or at the same point on the scale. Also, as one becomes more expert in the (any) task, the curve of efficiency shows a decided negative acceleration, which complicates our time-ability relationship.

The writer calls upon the reader to make his own interpretations of the data which are presented The writer has not attempted to do more than say that, if *A* works the board in six seconds and *B* works it in four seconds, then, by a rough practical criterion, *A* has more efficiency Regardless of relative starting points on any efficiency scale and regardless of the fact that increase in efficiency comes more and more slowly as practice continues, the writer is still of the opinion that, at any point of development, *the S who can work the board more quickly than another is more efficient* We have measured efficiency in terms of the amount of time needed to do a given, set unit of work

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WEIGHT-HEIGHT RATIO AND PERSONAL ASCENDANCY

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The anthropometric characteristics of prominent persons have long been of interest to students. It has been conclusively demonstrated that superior height and superior fame are associated Ellis (3), Kassel (7), Rose (11), Sorokin (13), Gowin (4), and Hrdlička (6) report this fact for prominent adults Terman, Baldwin, and their associates (14), and Hollingworth (5) have demonstrated that intellectually superior children are taller and heavier than ordinary children, and that they also tend to be socially ascendant. Caldwell and Wellman (2), Bellingrath (1), Poindexter (10), and Smith (12) have reported a similar height superiority for leaders as contrasted with non-leaders and followers Weight, because it is closely correlated with height, is also likely to be greater for ascendant persons than for the average of the population, or for followers, although an exception has been mentioned by Smith (12), in a study of Indians

Variability among outstanding people in height and weight, especially among so-called men of genius, is pronounced Ellis (3), indeed, considers variability to be the prime expression of the man of superior originality, achievement, and social recognition Kretschmer (8) goes even farther and, while distinguishing different physiques, most of which are definitely associated with certain mental and personality characteristics, points out that all physical types have their representatives among men of genius

The relationship between body build and ascendancy is a complex problem because personal ascendancy is of several types. Executive leaders in social groups, in the business world, in politics, leaders in art, literature, and music; leaders in intellectual life; child and adult leaders, leaders in small and in large social situations, and leaders both in static and in critical and changing situations are embraced under the general heading of ascendant persons Some are expert managers of the conflicting personalities about them, some are leaders because of originality and creative intelligence, and some lead because they guard and support the patriotic, religious, and other in-group symbols capable of drawing out emotional responses from the masses of men In spite of diversity of types of ascendant persons, however, it is of as much importance to determine to what extent certain characteristics of bodily proportion are common to ascendant persons of all sorts as it is to study each specific type separately.

One satisfactory method of studying the relationship between body build and personal ascendancy is to compute the weight-height ratio or coefficient[1] of ascendant individuals and to ascertain if it is greater than that for the total population or for non-ascendant persons of the same general characteristics

Hollingworth (5) found that 45 children of more than 135 IQ had a median weight-height ratio of between 130 and 135, as compared with a ratio of between 115 and 120 both for children of IQ's between 90 and 110 and for children of less than 65 IQ Such a difference is sufficient to make it clear that there is very likely a reliable degree of superiority in weight-height ratio for children of strikingly superior intellect. Baldwin (14) in the study of California children of superior intelligence found that both boys and girls were more often overweight than underweight for their height and age It is, of course, impossible to argue that such evidence demonstrates an association between weight-height ratio and intelligence. Several writers have claimed this, but Paterson (9) points out that the most carefully controlled studies have revealed only a slight positive correlation between various complex physical measures and intelligence.

Data on weight-height ratio of eminent men are very inadequate, but by computing the ratios from Gowin's (4) data, a partial answer may be had Table 1 shows that persons who held superior positions in a given occupation had larger ratios than those holding inferior positions. The amount of superiority ranged from 5 per cent for city school superintendents compared with principals of schools in small towns to 18 per cent for salesmanagers and railroad presidents compared to salesmen and station agents, respectively.

Data on ratios for student leaders and followers are also limited but those that are available show a slight superiority in weight-height ratios

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[1] The formula most commonly used is $\frac{100 \text{ weight}}{\text{height}}$ = weight-height ratio.

TABLE 1
WEIGHT-HEIGHT RATIOS FOR LEADERS OF SUPERIOR AND INFERIOR POSITIONS WITHIN THE SAME OCCUPATIONAL GROUP

Position	Weight-height ratio*
Bishops	249
Preachers small towns	232
University presidents	256
Presidents small colleges	235
City school superintendents	253
Principals small towns	226
Presidents state bar	243
County attorneys	232
Sales managers	268
Salesmen	227
Railroad presidents	263
Station agents	223

*Computations by the present writer.

for boy leaders, and disagreement concerning girl leaders and girl followers

TABLE 2

	Bellingrath (1)*	Smith (12)
Boy leaders	214	226
Boy followers	209	221
Girl leaders	195	194
Girl followers	184	202

*Computations by the present writer

The fact that Smith's data were for Indians may account for the disagreement of the studies Hollingworth has reported (5) a slight superiority in intellectual status of child leaders over their followers. This fact, together with the association between superior intelligence and weight-height ratio, already mentioned, supports the results of Bellingrath for leaders of both sexes, and of Smith for boys.

Such data are too inadequate to prove much, a general picture of the relationship between weight-height ratio and ascendancy cannot be obtained from four studies, and there are not even sufficient data for a conclusion concerning one type of personal ascendancy But the significance of the weight-height ratio justifies a few additional comments The ratio clearly has physiological implications First, it is considered by some writers to be an index of nutrition Second, Gowin (4) has pointed out that superior height and weight are associated with energy which, in turn, is a powerful factor in leadership. Third, body build is related to glandular constitution and activity For example, many thin persons are influenced by hyperactive thyroid or suprarenal glands, while obesity, and consequent high weight-height ratio, is associated with hypothyroidism and relatively sedentary physical habits, and hence with lack of sufficient effort to lead in certain situations. And fourth, body build is related to age in a positive manner.

It is obvious that body build is much more important during the critical period of leadership than afterward Even practical leaders, after they are firmly established in positions of authority and power, may step beyond limits in body build that would effectively prevent a rise to leadership if they had to compete with other ambitious men for the positions they hold. This fact partly explains the weight-height ratios of such groups as sales managers and railroad presidents (Table 1), which are somewhat above the most favorable ratio for leadership at earlier ages and in periods of actual rise to positions of leadership.

The prestige effect of body build, aside from the factors of strength and energy associated with body build, is of slight importance in personal ascendancy. Large size is probably impressive to potential followers, but well-proportioned persons of average size are little if any more impressive in a leadership sense than poorly proportioned persons of the same height or weight. Athletic prowess and gracefulness of small as well as large persons impresses most observers favorably, but contributes nothing to chances for leadership in anything except athletics, dancing, or in some position that depends to a great extent upon physical fitness

Research on this problem should be directed toward the relationship between weight-height ratio and ascendancy in various types of social situations, the situations being defined by the spatial and social location, the characteristics of the persons concerned, and the type of activity in which ascendancy occurs It seems likely that for each social situation there are limits to the weight-height ratio of successful leaders. If the ratio is too low, the person is lackadaisical and easily fatigued, and is hence likely to be unsuccessful in types of leadership which require strength and endurance If the ratio is too high, and the person is inactive, not because he does not possess energy enough, but because his energy cannot easily be released in leadership activities, he is again unlikely to be a leader Beyond as yet indefinite, but certainly broad, limits of weight-height ratio, it seems probable that permanent administrative leadership will be very rare if not entirely absent, while the limits will be even more restricted for the period during the rise of the person to the position of leadership.

Mental and artistic leadership, however, is much less restricted by body build than is leadership requiring great physical effort. The presentation of stimuli to others, the clash of wills, the effort to persuade or influence other men, are much less necessary in symbolic than in executive leadership. Energy of course must be available for supporting long hours of work requiring attention and energetic thought or action of the muscles required in painting or writing, but the limits of body build are broader than they are for success in executive leadership Body build, *per se*, is apparently of even less importance as an aid to artistic and intellectual leadership through the agency of prestige than it is to practical leadership of the face-to-face variety

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IMAGERY—TO WHAT EXTENT IS IT A FUNCTION OF THE MAZE PATTERN?

THURMAN C SCOTT

Sackett (4) calls attention to the fact that about two-thirds of his S's used visual imagery in learning, and about three-fourths of them used it in rehearsing the maze pattern. Only about one-fourth of his S's used the verbal method, and a much smaller percentage used the motor method.

He points out that this distribution of methods of attack in maze learning is different from that found by Warden (7), Husband (1), Lambert and Ewert (2), and Scott (5)

A comparison of the findings of the above authors would seem to indicate that this difference is due to a difference in the types of mazes used, that the maze pattern itself is a rather important factor in determining the type of imagery used Husband (1) suggests this answer, but unfortunately uses mazes some of which, because of lack of difficulty or lack of reliability, do not indicate this clearly In comparing four types of mazes, *S, F, X,* and *T*, he finds that comparable groups behave differently when confronted with these maze patterns of different construction This means, then, as he states, that there are no types of individuals who fall universally into certain methods of learning He fails, however, in the case of the *S*- and *T*-type mazes, to find how frequently a maze of a certain type calls forth a certain method of attack—in the *S*-type largely because of much retracing and lack of reliability in general, and in the *T*-type because of lack of difficulty of the maze He concludes that for mazes of *S*-, *F*-, and *X*-type, the verbal or counting method is the predominating and most efficient one This is particularly true of the *X*-type and is least true of the *S*-type maze. In fact, he finds that the *X*-type can be learned only with the greatest difficulty by any other than the verbal or counting method It is extremely difficult by the motor method. The evidence, however, is not so clear for the *T*-type (circuitous) maze which Sackett used The reason for this is that this maze proved to be too easy to call forth any predominant method Husband found, though, that visual imagery occurred more frequently with this type maze, about one-fourth of the S's stating that they had gotten a mental picture of the correct pathway

The present writer has obtained results (5) which corroborate Husband's findings, and indicate still more clearly the importance of the maze pattern as a factor in determining the type of imagery used by the S's In using a maze (maze *C*) identical in pattern and construction to Husband's *S*-type (old type stylus maze), he obtained results which differed but little from those of Husband. Husband found that the motor method predominated, the verbal method was second in importance, and the visual method was a poor third. The present writer believes that, in his study, the verbal method was predominant, with the motor method a very close second, most of the S's using a combination of these two methods The visual method was the exception rather than the rule. Warden (7), using the same maze, found that 18 out of 40 S's used the verbal method, 12 the visual, and 10 the motor method, the verbal method being about four times as efficient as the motor and twice as efficient as the visual. The present writer, using the same pattern stylus maze, but one in which the stylus fit *snugly in the* *groove,* found that about two-thirds of the S's used the verbal method in whole or part The same was true of the same pattern in high relief form (Husband's *F*-type) (1) No S's were found using visual imagery in learning these last two mazes The author's findings (6) with the *X*-type mazes also agree with Husband's results in that this type maze practically forces the *S* to use verbal imagery In reference to Husband's *T*-type maze, the author, using one of similar pattern but of stylus construction, obtained results which clearly indicate that visual imagery predominates here This maze, which in this study (5) was labelled *E,* is very similar to the one used by Sackett and the results are practically the same as his. Nine of 12 S's learned this maze with a combination of visual and motor imagery, aided somewhat by verbal cues. Two S's learned it in a purely verbal manner and one S in a motor manner These last three S's had much poorer records than the nine who used the visual-motor method The prominence of motor and the presence of verbal imagery here was unquestionably due to the fact that maze *E* was the second of a series of mazes which these S's learned It was preceded by maze *C,* already referred to, a maze of the old stylus type, identical in pattern to Husband's *S*-type maze, and a maze which the author has found usually calls forth verbal or motor imagery or a mixture of the two, and very rarely calls forth visual imagery. In fact, these 12 S's, as nearly as can be determined, can be classified on maze *C* as follows four used the verbal method, two the motor, and the other six a combination of the two None of them used the visual method the first day On the third day, after learning *E* the second day, these S's were again given maze *C* without being told that it was the same maze, and can be classified as follows: seven verbal, one motor, and four combination of these two. This would seem to indicate that the predominance of visual imagery used in learning maze *E* is not due to any peculiarity of the S's or conditions of the experiment, but is due to the pattern of *E.* It would also seem to indicate that there would have been less motor and verbal imagery present had *E* been the first rather than the second maze learned It was rather evident that the two S's who learned *E* in a purely verbal manner and the one S who learned *E* in a motor manner had developed these methods of attack the first day in learning maze *C* and were holding on to them the second day at all costs

In this same study (5) the author found further evidence of the importance of the maze pattern in determining the type of imagery used This is in connection with mazes labelled *N* and *W.* These are stylus mazes of the so-called *T*- or *U*-type, the only difference being that the middle part of the head of the *T* was a shallow *V* rather than a straight line The outer ends of the head, however, were perpendicular to the stem Maze *N,* like *E,* was preceded by maze *C,* a maze which, as has already been pointed out, calls forth in somewhere nearly equal degrees verbal and motor types of imagery. Shifting to *N* caused a change of imagery or method of attack, the most striking being a change from verbal to motor Eleven of the 15 S's in this group made a distinct shift toward motor imagery in learning *N*. In a few cases, a complete change was made from verbal to motor imagery. In only one case did a pure verbalizer remain so when he learned *N* Maze *W* was of similar design, and practically the same statement could be made about it. *W*, however, like *E*, was followed by maze *C* the third day, and there was a rather pronounced shift back to verbal imagery on this last day, only two of the 12 S's depending mainly upon motor imagery. These two used the motor method straight through.

Scott and Henninger (6), using the Warner-Warden bilaterally symmetrical maze, both in stylus and high relief form, and Allison's version of this in high relief form, find further evidence of the fact that the imagery or method of attack may be a function of the maze pattern. The four-alley length of this alternating maze (only Allison's maze was used in this length) was too easy to call forth imagery to any great extent, but the eight-alley lengths, while still quite easy, did cause the S's to develop a rhythm in their movements which led them frequently to run through the mazes perfectly before they were aware that they knew the pattern This rhythm was developed with very little thought, and was for the most part thrust upon the S's by the pattern of the maze.

Perrin's findings (3) in regard to imagery seem at first thought to be contradictory to the above results He found, as Sackett states (4), that each of his S's was inclined to adhere to his particular image equipment for all mazes. This conclusion, however, becomes less contradictory when examined carefully In the first place, the patterns of all four of his mazes were so irregular that it could hardly be said that there were radical differences between them, and there would be little basis for predicting that they would call forth distinctly different types of imagery In the second place, it was actually found that there was very little uniformity of imagery on any one maze, this being due, it seems, to the fact that the mazes were so unsystematic. One of them was a modification of the old Hampton Court maze and the other three were equally lacking in plan and reliability. In the third place, Perrin states that he was unable to find any correlation between the type of imagery used and the efficiency in maze learning This finding, which has not been verified in more recent studies, is due, it seems, to the unsystematic patterns of the mazes used and to the fact that, when such patterns are used, many S's use several types of imagery That is, they will use different kinds of imagery for different sections of one maze. Such S's, of course, cannot be classified as belonging to this or that distinct imagery type.

Lambert and Ewert (2) also find no great difference in methods of attack when two mazes are learned successively This, however, also does not contradict the author's findings, since these two mazes were of the same general design They were of the Pechstein adjustable design and were both somewhat distantly related to the circuitous type. And, as might be expected, a larger percentage of the two groups used visual imagery than would ordinarily use it on a non-circuitous maze. On the first maze, 40 per cent of the combined groups used visual imagery, and *on the second 35 per cent used it*

DISCUSSION

It might be well to attempt to answer the question why these particular types or patterns of mazes call forth these particular methods of attack In the case of the old-fashioned stylus maze, such as Husband's *S*-type, where the stylus fits loosely in the groove, and where a certain amount of retracing may be allowed, it is very difficult for the subject to analyze the maze into its moves or units In fact, quite frequently he is not able to do this at all and learns to get through the maze without ever having a very accurate picture or idea of the maze pattern He learns the maze, too, *with a great deal of difficulty, this difficulty being accompanied* by a certain amount of emotional strain. A subject, when hard pressed in this manner, will attempt to profit by any experiences which may be used to adadvantage, *regardless of how varied they may be. A cue of one type may* occur to him at one point in the maze and a cue of an entirely different type at another point Because of the emotion and the inaccuracy of his *ideas of the pattern, it may never occur to him that either type cue could* be used at any other point in the maze or throughout the maze It is not surprising, then, that one occasionally finds mixtures of verbal, motor, *visual, and even auditory imagery in one subject in* the learning of one maze of this type. Motor imagery probably occurs here more frequently than any other kind, since any other type of behavior, it seems, would be more dependent upon analysis of the pattern If analysis is very difficult, there is nothing left to do but to depend upon kinesthesis

In using this type of maze, the author did not allow retracing, and believes, for this reason, that his subjects were able to analyze the pattern somewhat more easily than Husband's S's, and consequently used more verbal imagery.

In the case of mazes *N* and *W* (old stylus type), however, where, in addition to the vertical and horizontal moves, a third directional movement was introduced, most S's gave up any attempt to analyze the maze into units. One could slip so easily from the stem of the *T* into the *V*-section of the head and from that into the horizontal section that it was very difficult to realize just where a change of direction was made, and many S's became quite confused in regard to directions actually traversed. Unit analysis is extremely difficult in a situation of this kind, and most S's, as stated above, fell back on motor imagery

Analysis of the maze pattern is much easier in the improved form of the stylus maze where the stylus fits the groove snugly. As has already been pointed out, the writer obtained the same results with this maze that he did with an identical pattern in high relief form (Husband's *F*-maze), about two-thirds of both groups of S's using the verbal method in whole or part In these mazes all correct vertical moves lead away from the S and most S's soon learn that the critical points are where the stems of the *T*'s join the heads. In other words, they soon learn that a vertical move offers no possibility for error, and that the only question they must decide is whether to turn to the right or left at the end of this move The next step is to count the number of lefts or rights occurring together, use some system of grouping these numbers, and the S has completed the best method for this type of maze—the verbal method.

The motor method, however, can be used on this maze, as is evidenced by the fact that something like one-third or one-fourth of the S's depend mainly upon it The reason for this is that the correct moves to the right or left lead one, by degrees, depending upon the number of moves in one direction in succession, away from the more or less arbitrary mid-line in the maze connecting the starting point with the goal The S develops a "feeling" in his arm to go so far to the right at this point and not so far at that point An S using this method, though, has a great deal of difficulty with those moves which fall on or near the mid-line. His discrimination, in terms of kinesthesis, is not accurate enough to determine his distances at these points, and this results in his making many more errors here than would be necessary with the verbal method.

This is the reason why the motor method can hardly be used on the *X*-type maze All the moves in this maze are equally distant from the middle, each one starting from the mid-line and consisting simply of a brief excursion out to the right or left and back to it again. In other words, all of these moves are identical kinesthetically in terms of their extent to the right or left of this mid-line connecting the starting point with the goal. The motor cues are reduced to a minimum and the S's are practically forced to use the verbal or counting method

The circuitous maze is in a class to itself It differs from the mazes discussed so far in that, in addition to right and left turns and vertical moves away from the S, vertical or perpendicular moves back toward the S are introduced. This makes it more difficult for the maze to be learned in terms of rights and lefts, because the S cannot take his position as reference point for all these moves If the S insists on using this method, he must abandon his position as reference point and imagine himself bodily traversing the pathway in the maze as he would a road or street turning to the right here and to the left there These rights and lefts, however, are difficult to remember, since his imaginary position is continually shifting as he changes directions These mazes can be learned in this manner, but the more normal and efficient method is to visualize the pattern in some manner. Some S's visualize it in terms of city blocks or squares of land Others see the maze as a map, the pathway being the boundary line which separates a state or country from surrounding states or countries. Still others think of the pattern in terms of geometric designs which are made up of straight lines and right angles In fact, there may be a great deal of variation here in regard to the actual elements of the thought process, but in most cases visual imagery is the basis for them The S merely has to traverse the maze a time or two to see a rather definite form or outline begin to take shape This may be reinforced in spots by motor or verbal imagery, but by far the greater part of the outline is obtained too easily and quickly to be verbal or motor in nature Verbal imagery, it seems, requires a certain amount of effort and forethought on the part of the S, and motor imagery requires effort and time Neither requirement is particularly evident here in the case of visual imagery It occurs without much effort, forethought, or time, the reason being that we have had many experiences which fit us for such a task. If S's could be found who had had no experiences with city streets or squares of any sort, with maps, nor with geometric designs, they might not visualize here so readily Such S's, however, cannot be found, and, since such visual experiences make up so important a part of our daily lives, it is to be expected that they will be drawn upon and frequently transferred in whole to the solution of an artificial problem like that which confronts us in a maze situation.

SUMMARY AND CONCLUSIONS

It would seem, then, that the maze pattern itself is a very important factor in determining the type of imagery or the method of attack used by the S in learning the maze. Any maze which is systematic, and is reducible to some common unit, is found to call forth in the majority of cases a certain type or types of imagery peculiar to it It is only the unsystematic maze, the one which is not reducible to a unit of construction, that not only calls forth varied types of imagery in one S, but may produce a variation in imagery from S to S.

1 The old type stylus maze of Husband's *S*- or the author's *C*-type is found to call forth verbal and motor imagery in about equal quantities.

2 The author's new type stylus maze and Husband's *F*-type high-relief maze are found to call forth verbal imagery in about two-thirds of the S's

3. The author's *N* and *W* old type stylus mazes involving three directions are found to call forth motor imagery in practically all S's

4. Husband's *X*-type high relief mazes are found to require verbal imagery of all S's.

5 The circuitous mazes used by Sackett and the author are found to call forth visual imagery in from two-thirds to practically all S's

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BOOKS

EVELYN DEWEY *Behavior Development in Infants A Survey of the Literature on Prenatal and Postnatal Activity, 1920-1934.* New York, Columbia University Press, 1935 Pp viii + 321.

Under the sponsorship of Dr. Myrtle B McGraw, Dr L. Beverley Chaney, and Dr Frederick Tilney, the author of this volume, with assistance from other workers, has brought together a survey of much of the most significant current literature on the growth of infant behavior. The purpose of the survey is not to cover all of the literature in this complex field, but rather to select and organize some of the most salient results available as a result of recent research.

The first section of the book is devoted to a brief consideration of theories of development Reference is here made to the correlation of structure and function from animal studies, with especial reference to the correlation of the myelinization of the nervous system and behavior The reader will especially profit by the clear review of the work of Dr. Tilney presented in this section

The next part of the book deals with development during the fetal period Although very brief, this section, within its compass, gives the reader a real introduction to the present status of the scientific knowledge of this period. The section dealing with the neonatal period is possibly more complete. The point is clearly made, however, by detailed reference to relevant studies, that practically all of the reactions recorded in this period have been developing *in utero* and are possible during the fetal period under appropriate conditions The book's organization seems to emphasize separate periods of development, but it is clearly pointed out in a number of places that any break in the sequence of development is purely arbitrary

In the section of the book dealing with infancy, studies dealing with locomotion, hand and arm reactions, and the reactions of problem solving and language are most fully dealt with

In conclusion the question is raised whether it is not possible that a tendency to discard the older reflex-arc view of behavior may not have gone too far In this connection a plea is made for the full consideration of growth processes which seem to involve specific as well as organismic changes

No two trained workers in this field would probably have singled out exactly the same studies from the large literature available concerning child development It seems clear, however, that the selection and interpretation given in this volume is certainly useful The book is sure to be of assistance to many students of the growth of behavior, and indeed all who are interested in this field must feel grateful that the book has been written and published

One or two minor bibliographical errors have crept into the volume, but no one of these is such as seriously to interfere with the satisfactory identification of the reference in question The inclusion of authors' names in the index would have been valuable

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A REPORT ON THE TEST-RETEST PERFORMANCE OF 38 COLLEGE STUDENTS AND 27 WHITE RATS ON THE IDENTICAL 25-CHOICE ELEVATED MAZE*

From the Department of Psychology and Education of Maryville College

Clark Lathan and Paul E. Fields[1]

Since the publication of Husband's article (1) in which he compared the maze learning of human adults and white rats, his data have been widely quoted as representative of the learning of the species involved, although he clearly stated that some of the comparisons were not to be taken as conclusive because of the differences in techniques involved In order to test these conclusions and at the same time secure some comparative data on the retention of the maze habit, a somewhat similar experiment was performed under more nearly identical physical conditions for the two groups of subjects. Mr. Lathan completed the experimental work in the spring of 1934 and the members of a class in Statistics under Miss Gamble completed the statistical analysis of the data the following year.

In the present study the same maze was learned by groups of humans and rats under as nearly equal physical conditions as could be achieved. The points of similarity (identical for humans and rats) were (*a*) preliminary orientation was attained by use of a straightaway, (*b*) the same maze was used for both groups, (*c*) the number of trials per day was constant, (*d*) learning criteria were identical, and (*e*) a rest period of the same time interval was followed by retraining until the original criteria were met

The obvious points of dissimilarity were, (*a*) the motivation was not equated, (*b*) the humans walked on the floor and followed the pathway with their hand, while the rat's entire body was on the elevated path, and (*c*) the human was blindfolded, the rat's vision was not obstructed.

One other factor has been mentioned which was supposed to

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[1] Presented before the 1935 meeting of the Southern Society for Philosophy and Psychology

work to the disadvantage of the human subjects It was assumed that humans were not accustomed to walking about blindfolded in maze situations, and that the rats were right at home in such an environment. It is the writer's belief that the rats were at a disadvantage, instead of the humans. They exhibited more "nervousness" and "emotional" behavior as the result of being placed on a strip of wood one inch wide, thirty inches above the floor than did the humans when they were blindfolded and walked on the floor with their hand on the maze as a guide rail The rats had never been outside of their living cages nor had they had any maze experience until they were started on the problem, thus the environment was an entirely new one for them

APPARATUS

The straightaway was four units (12 feet) long Each unit was built of 1 inch material, the part the rats traversed being 30 inches above the floor and 36 inches long These units were drilled in the middle of each end and 9 inches and 18 inches from each end so that they could be fastened together with nails to hold them more rigidly in place. This was especially necessary with the human subjects or they would have knocked the maze down by body contacts It was also a help with the rats for the greater stability did away with *slight movements which always made them run more cautiously*

The plan of the maze used is shown in Figure I. It was constructed of 37 units so arranged as to give ten right and ten left turns in the true pathway, which was 45 feet long. At five of the choice points the subjects were to run straight ahead and not turn Ten of the 20 turns were T turns. There was no provision to prevent retracing. The maze was cleaned before each day's trials.

METHOD

Subjects There were 38 human subjects, 19 college students of each sex, no relatives, and 27 white rats, 14 males and 13 females representing eight different litters from 4-7 months old

Preliminary Training The humans were blindfolded, hand put on top of the straightaway and told to follow it until the experimenter said "The end." They were given three trials in one day on this straightaway. No additional statement was given when

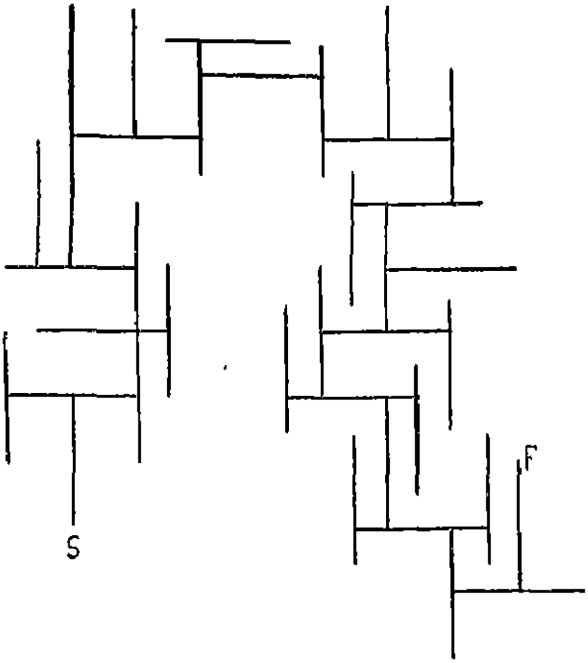

FIGURE 1
MAZE PLAN

transferred to the maze on the following day. The rats, after a 24-hour starvation period, were placed on the straightaway with food at the end After three trials in one day they were transferred to the maze The average weight when started on the straightaway was 165 grams, and they lost about ten grams apiece during the time they were learning the maze. Thus the hunger drive was not extreme

Criterion Members of both groups were given three successive trials per day and were removed from the maze as soon as they met the criterion of one day's runs with no errors. Exactly 30 days after meeting the criterion each subject was brought back for the retest (*none of the subjects knew that they were to be retested*). *The time* of the run was constant from day to day

Results

Means, standard deviations and the reliability of the differences. The means and standard deviations for the two groups on twelve different measures, together with the reliability of the difference between the means are presented in Table 1. For the original learning, the rats were reliably better than the humans on ten of the twelve measures The total time and the total errors show no reliable differences between the two groups, but when the first two trials were omitted the rats were definitely superior. The rats also met the various criteria of one errorless run, two and three consecutive errorless runs, and three errorless runs in the same day in fewer trials than did the humans. The rats were less variable on all measures except total time, for which there was no reliable difference between the means.

TABLE 1

Means for Original Test

	Humans N-38		Rats N-27		$\frac{D}{\sigma_{diff}}$
	mean	*sigma*	*mean*	*sigma*	
Trials to meet criterion of 3 errorless runs in same day	22,26	9.74	16.28	4.54	3.31
Trials to meet criterion of 3 consecutive errorless runs	19.68	9.56	14.11	4.72	3.10
Trials to meet criterion of 2 consecutive errorless runs	18.00	8.81	11.30	4.61	3.99
Trials to meet criterion of 1 errorless run	13.11	5.64	7.67	1.68	5.61
Total time	3137.47	1162.25	2636.88	1473.00	1.47
Time, first two trials out	2443.23	1477.25	765.59	477.50	6.54
Total errors	88.13	50.80	75.44	36.88	1.17
Errors, first two trials out	59.55	38.86	24.96	17.78	4.82
Forward going errors	77.00	42.67	53.74	21.83	2.87
Forward going errors, first two trials out	54.47	35.27	20.44	11.32	5.56
Forward errors less duplicates	72.24	38.64	38.06	12.04	5.11
Forward errors less duplicates, first two trials out	54.34	35.34	19.54	8.74	5.82

As shown by Table 2, the relearning data present a different picture. The humans were better than the rats on each of the five measures where reliable differences were obtained, namely, the number of trials required before making one errorless run and two consecutive errorless runs, total errors, forward errors, and forward errors less

TABLE 2

MEANS FOR THE RETEST

	Humans N-38		Rats N-27		$\frac{D}{\sigma_{diff}}$
	mean	sigma	mean	sigma	
Trials to meet criterion of 3 errorless runs in same day	3.39	2 22	4 50	2 00	2.10
Trials to meet criterion of 3 consecutive errorless runs	1.42	1 94	2.15	1.78	1 56
Trials to meet criterion of 2 consecutive errorless runs	92	1 48	2 04	1.48	3 00
Trials to meet criterion of 1 errorless run	.45	1 02	1 96	1 43	4.73
Total time	410.81	236.50	525 59	331.50	1.54
Time, first two trials out	209.55	164.50	162 70	103 25	1 41
Total errors	1 50	2 23	11.37	8 52	5.88
Errors, first two trials out	.65	1 59	96	1.87	.70
Forward going errors	1 42	2 15	7 88	6 20	5.20
Forward going errors, first two trials out	.65	1 59	85	1 46	.52
Forward errors less duplicates	1 55	2 15	6 26	4.56	4.98
Forward errors less duplicates, first two trials out	68	1.91	85	1 58	.38

duplicates. As a group the rats had learned more rapidly than the humans, but they also forgot more rapidly The fact that the number of trials required to meet the criterion of three errorless runs in one day was not reliably different indicated that the rats relearned the *maze very rapidly The rats were less variable on five of the twelve* measures on the retest, but none of these had reliable differences between the means.

Learning data When the error data shown in Table 3 were inspected, it was seen that with the exception of the very first trial, the rats were always below (superior to) the humans. The error data for the retest showed the humans were superior on the first three trials, but not as accurate as the rats thereafter

The time data in Table 3 for the original learning showed the rats to be superior to the humans on every trial except the first two On the retest, with the exception of the first trial, the rats were *better than the humans all the way.* These data indicate that the humans had the advantage on the first trials, but that it was then lost and the rats ran more rapidly and with fewer errors thereafter.

Distribution of errors Table 4 presents the average number of errors per blind alley for the two groups of subjects These data

TABLE 3

AVERAGE TIME AND ERRORS PER TRIAL FOR HUMANS AND RATS

	Test				Retest			
	Time		Errors		Time		Errors	
Trials	Humans	Rats	Humans	Rats	Humans	Rats	Humans	Rats
1	472	1632	18 2	40 0	111	307	5	8 9
2	221	256	10 5	10 4	89	61	3	1.5
3	163	117	7 4	3 2	80	40	.2	.5
4	209	126	7.0	5 6	78	51	4	.4
5	239	64	6 4	2 8	72	41	3	.1
6	134	51	4 4	1 6	69	34	2	.0
7	148	48	4 3	1 8	53	43	0	.0
8	125	39	4 0	1 5	55	37	0	3
9	106	40	3 8	1.5	60	35	0	.0
10	118	45	3.6	1 9		37		.0
11	101	35	2 4	1 3		30		.0
12	101	30	2 2	5		30		.0
13	114	35	2 2	8				
14	93	34	2 0	7				
15	88	31	1.6	.5				
16	107	30	1 8	9				
17	106	27	1 4	7				
18	83	25	1 1	4				
19	90	32	1 5	.5				
20	84	30	9	.5				
21	79	24	8	.4				
22	92	29	1.3	.0				
23	76	23	.8	.5				
24	71	22	.3	3				
25	81	18	1 2	0				
26	70	16	1 1	0				
27	70	16	9	0				
28	73		.9					
29	66		.5					
30	68		9					
31	69		1.0					
32	66		.8					
33	63		3					
34	67		1 3					
35	57		7					
36	57		.7					
37	63		0					
38	54		5					
39	54		1 0					
40	58		2.5					
41	43		1.0					
42	42		1 5					
43	58		5					
44	53		5					
45	51		5					
46	52		1 0					
47	55		.0					
48	55		2 0					
49	55		1.0					
50	56		1 0					

TABLE 4

DISTRIBUTION OF FORWARD ERRORS LESS DUPLICATES PER BLIND ALLEY

Number of blind	Type of blind	Direction of choice	Average error Humans	Rats
1	T	R	473	4 11
2	T	L	1 37	1 67
3		S	6 68	2 67
4		S	3 26	1,33
5		L	7 00	2 29
6		R	368	2,88
7		R	790	1 59
8		S	3 03	1 18
9	T	L	3 42	296
10		R	1 74	1 63
11	T	R	1 13	.407
12		L	3 87	1 22
13		S	1 29	,074
14	T	R	406	407
15	T	L	5 63	741
16		R	324	704
17		S	2 84	.407
18	T	R	895	2 10
19	T	L	1 92	33
20	T	L	7.98	1.67
21		R	869	1 67
22	T	L	4 75	1 26
23		R	3,03	3 85
24		L	3,82	1 48
25		L	4 47	1 40

are further analyzed with respect to the type of intersection and direction of the correct path in Table 5. From this analysis it is evi-

TABLE 5

DISTRIBUTION OF FORWARD ERRORS LESS DUPLICATES ACCORDING TO THE TYPE OF INTERSECTION AND THE DIRECTION OF THE CHOICE

No and type of intersection		Percentage of error Humans		Rats	
10	T-intersections	317		346	
	5 R choices	045	(141)	206	(.597)
	5 L choices	272	(859)	140	(.403)
5	S	,239		149	
	1 R	093	(390)	,071	(470)
	4 L	146	(609)	,078	(530)
5	R	,095		311	
5	L	347		191	

dent that the *T*-intersections accounted for an equal per cent of each group's errors, but of these, the left turns accounted for 86 per cent of the humans' errors and only 40 per cent of the rats' errors The intersections at which the correct path was continued straight ahead accounted for 24 per cent of the humans' incorrect responses, and only 15 per cent of the rats', with one right turn contributing more than twice its proportionate share of errors. The five intersections where the correct path turned to the right (not *T*-intersections) contributed 10 per cent of the human's total errors and 31 per cent of the rats' errors The five left turns of the same type furnished 35 per cent of the human's errors and 19 per cent of the rats' errors. The humans had established some kind of a "right turn tendency" which did not seem to affect the rats.

The maze was divided into three parts and the per cent of error determined for each section As shown by Table 6, the middle section, even though it had one more blind alley than the other sections, was the least difficult. On the original learning, the first and last sections were of about equal difficulty for the humans, but the first section was decidedly harder for the rats. On the retest the first section was the hardest for both groups.

TABLE 6

DISTRIBUTION OF ERRORS

	Original Test				Retest	
	Total errors		Forward errors less duplicates		Total errors	
	Humans per cent	*Rats* per cent	*Humans* per cent	*Rats* per cent	*Humans* per cent	*Rats* per cent
First section (Blinds 1-8)	35	60	32	47	40	45
Middle section (Blind 9-17)	30	15	29	16	25	14
Final section (Blinds 18-25)	35	25	39	37	35	41

When the number of the alley was correlated with its actual difficulty as measured by the number of errors made on it, a positive correlation would indicate that the last part of the maze was the hardest As shown by Table 7, only one correlation is significant (—.59), and it shows the first part of the maze to be the most diffi-

TABLE 7

CONSISTENCY OF MAZE

	Humans	Rats	
1. Number of blind with its total errors. Original learning	025	—590	
2. Number of blind with its total errors Retest	—056	—095	
3. Number of blind with its forward errors less duplicates Original learning.	141	—247	
4 Difficulty of alleys on the test-retest.	824	747	
5 Total errors per alley of humans with rats Original learning			111
6. Total errors per alley of humans with rats Retest			056
7 Forward errors less duplicates per alley for humans against rats Original learning			023

cult for the rats. There was no correlation between the kind of errors made by the humans and the rats, although there was a consistency in the difficulty of the alleys in the test-retest situation as shown by the correlation of .83 for the humans and .74 for the rats

The average errors per trial for the 8 most difficult blind alleys shown in Table 8 indicate that the alleys were not all of equal difficulty and that they differed in that respect between the rats and the humans

Reliabilities. Rank differences and Pearson product-moment correlations were worked for all these data. There was very little difference in the size of the correlations, but in some cases the Pearson correlations were somewhat lower Only Pearson correlations are reported in any of the tables of this study.

As shown in Table 9, the odd-even correlations were uniformly higher for the humans, their lowest one being 826 but with three of the rats' being insignificant When the human correlations were corrected with the Spearman-Brown formula for halving the data, all were raised above 90 The effect of including the first two trials was clearly seen in the case of the total errors and the total time with the rats, where the r was .227 and .003 respectively, but with the first two trials excluded the correlations were raised to .884 (.94 corrected) and 934 (.97 corrected) respectively. In view of

TABLE 8

AVERAGE ERRORS PER TRIAL ON THE EIGHT MOST DIFFICULT ALLEYS

	Alley 1		Alley 3		Alley 5		Alley 12	
Trials	Humans	Rats	Humans	Rats	Humans	Rats	Humans	Rats
1	157	555	578	185	763	666	526	.666
2	.131	296	710	.407	.605	222	500	.259
3	000	222	631	185	.526	035	315	037
4	.000	259	684	185	657	296	236	037
5	026	.259	500	185	.500	148	263	.037
6	000	074	421	333	447	148	263	000
7	026	307	351	038	.378	115	.263	.000
8	000	.346	394	346	324	.000	162	038
9	026	.153	432	153	.270	076	.189	038
10	000	230	.257	038	.400	.228	171	.038
11	000	384	257	115	400	038	.142	000
12	000	153	200	.000	285	000	057	.000
13	026	166	151	000	303	083	151	000
14	000	125	181	166	181	047	030	000
15	000	041	151	208	.121	000	090	000
16	000	285	161	071	129	071	065	000
17	026	214	129	071	096	.071	032	071
18	000	214	161	000	.192	000	032	.000
19	.000	181	.071	.090	142	.090	071	.000
20			071		142	090	000	.000
21			071		035		071	000
22			050		.100		050	000
23			100		050		050	.000
24			000		100		000	250
25			.000		076		076	
26			.153		.076		.000	
27			077		152		.076	
28			100		000		100	
29			100		.100		000	
30			.100		100		100	
31			000		.250		000	
32			250		050		000	
33			000		000		250	
34			000		333		333	
35			333		000		000	
36			000		.333		.000	
37			000		000		000	
38			000		.000		000	
39			000		500		000	
40			000		.000		500	
41			000		000		000	
42			500		500		000	
43							000	
44							000	
45							000	
46							000	
47							000	
48							000	
49							1 000	
50								

TABLE 8 (*continued*)

Trials	Alley 16		Alley 20		Alley 23		Alley 25	
	Humans	Rats	Humans	Rats	Humans	Rats	Humans	Rats
1	605	333	.710	481	342	962	736	666
2	578	296	631	.555	.236	481	.631	.259
3	.500	074	578	222	.315	259	447	000
4	447	000	552	148	184	518	473	.037
5	236	.000	500	037	157	296	342	.037
6	.394	000	447	037	.131	111	289	111
7	270	038	540	037	081	162	216	.000
8	216		.513	.000	081	148	216	.038
9	351		567	000	054	.162	189	076
10	285		371	.000	057	.038	.166	000
11	236		297	000	085	.148	057	000
12	210		297	000	.114	074	166	000
13	.181		.272	000	181	083	121	000
14	151		303	.041	060	.047	.030	.041
15	212		151	000	.090	083	.090	
16	161		322	000	129	000	064	
17	.064		129	000	193	000	000	
18	032		096	000	097	071	032	
19	000		321	000	.178	000	142	
20	071		071	.000	071	000	071	
21	000		035	190	107	000	.000	
22	150		150		100		.050	
23	100		050		000		000	
24	050		050		.000		050	
25	153		.307		.077		076	
26	.076		230		.077		.000	
27	153		153		.077		.000	
28	200		.100		100		000	
29	100		200		000		000	
30	100		200		100		100	
31	.000		.250		000			
32	000		000		250			
33	000		000					
34	333		333					
35	333		.000					
36	000		000					
37	000		000					
38	.000		000					
39	000		000					
40	.000		500					
41	500		500					
42	500							
43	000							
44	000							
45	1.000							
46	1 000							
47	000							
48	1 000							

TABLE 9

ODD-EVEN CORRELATIONS

		Humans	Rats
1.	Total errors	.83 (.90)*	23
2	Errors, first two trials out	84 (.91)*	88 (.94)*
3.	Forward errors	.89	27
4	Forward errors, first two trials out	87	.62
5	Forward errors, less duplicates	.91	.69
6	Forward errors less duplicates, first two trials out	92	77
7	Total time	89	—003
8	Time, first two trials out	89 (.94)*	.93 (97)*

*Coefficients in parentheses are corrected for halving the data

the fact that no attempt was made to prevent retracing, these reliabilities compare very favorably with those of other investigators. The test-retest correlations contained in Table 10 were all low, only 8 out of 20 attaining statistical significance Of these, every human correlation was positive and every rat correlation was negative. Evidently the mechanism accounting for retention in the two species is not very similar. Each human subject's percentile rank on the American Council's Psychological Examination (range of 9902 to .0282) was correlated with each of these criteria, but *no significant correlations were obtained.* With the exception of three correlations (total trials against total time for the humans and rats, and total time against time with the first two trials out for the rats) all

TABLE 10

TEST-RETEST CORRELATIONS

		Humans	Rats
1	Total errors	35	—33
2.	Average errors per trial	04	—40
3	Errors, first two trials out	.56	10
4	Forward errors	45	—23
5.	Average forward errors	11	—22
6.	Forward errors, first two trials out	52	.11
7	Forward errors less duplicates	51	—.13
8.	Total time	28	—57
9.	Average time per trial	.70	—43
10	Time, first two trials out	23	—.05
11.	Total trials	.28	—.17

TABLE 11

Miscellaneous Correlations

		Humans	Rats
1	Total trials with total errors	75	47
2	Total trials with total time	27	20
3.	Total time with total errors	50	71
4	Time, first two trials out with errors first two trials out	43	91
5	Total time with time first two trials out	.95	32
6	Total errors with forward errors	.96	98
7.	Total errors with forward errors less duplicates	89	.81
8.	Forward errors with forward errors less duplicates	97	.85

the others presented in Table 11 are significant. The higher correlations of total time and total errors with other measures for the humans indicate that they start out on the problem with an initial advantage over the rats Why this advantage was not maintained is not known

Summary

When 38 human adults and 27 white rats were trained on the identical maze under as nearly the same experimental procedures as possible, and then retested exactly 30 days after meeting the original criterion of three errorless runs in one day, it was found:

1 That the rats were superior to the humans on all ten of the twelve criteria in the original learning where reliable differences were obtained

2. The humans were superior to the rats on all five of the criteria on the retest where reliable differences were obtained.

3. In general, the rats were less variable than the humans.

4. The total time and error curves were very similar in shape, with the rat's curve usually below (superior to) that of the humans.

5. The outer parts of the maze were more difficult for both groups than the middle section.

6 The rats learned the last section of the maze before they did the first.

7. Learning curves for individual blind alleys and correlations between humans and rats show that different types of errors were made, confirming Husband's observation.

8 Reliabilities computed through errors and time on odd-even

trials of the original learning (first two trials omitted) were 91 and .94 for the humans and 94 and 97 for the rats

9. Test-retest reliabilities were low for both groups, but all correlations for humans were positive, and for the rats, negative. This seems to indicate a fundamental difference in the mechanism or nature of retention.

10. Husband's data indicating that humans learn in fewer trials, with less errors and in shorter time than rats are contradicted by these data which were obtained under more nearly identical conditions for both groups of subjects.

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VISUAL DISCRIMINATION IN THE CAT. IV THE VISUAL ACUITY OF THE CAT IN RELATION TO STIMULUS DISTANCE*[1]

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I INTRODUCTION

An important aspect of the understanding of discrimination in animals lies in the consideration of the limitations placed upon responses by the structure and function of different receptor mechanisms in relation to specific kinds of stimulation. A representative measure of the limits imposed upon responses mediated through the eyes is that of visual acuity, defined in terms of the angle, or the reciprocal of the angle, subtended by a just discriminable, discrete pattern at a given distance from the eye. Although this measure represents the capacity of the visual mechanism as a whole for resolving differences in detail due to radiant energy in the environment, it is mainly associated, for obvious reasons, with the degree of anatomical differentiation of the retina (Hecht, 8) and the nature of the accommodation apparatus.

Relatively unknown at this time are the restrictions placed upon the behavior of sub-primate mammals by the nature of the optical system, in so far as such limitations may be represented by visual acuity measures taken at various stimulus distances from the eyes This is true mainly because of the inadequate techniques which have been used in investigating the responses of such animals to special forms of stimulation Because these methods have usually given rise to negative results, the view is sometimes held that animals such as the dog, cat, and racoon possess deficient eyes and make little use

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of vision in their adjustments to their surroundings (Warden, Jenkins, and Warner, 30). Conclusions of this sort seem premature at present, especially when it is considered that Lashley's (19) results with pigmented and albino rats constitute the only positive data on specific visual acuity in mammals below the monkey

The consideration of the complexity of the visual mechanism of the cat, as well as the ability of the animal in finding its way about, emphasizes, as against the conclusions noted above, that this animal is significantly dependent, in its normal responses, upon vision, and that further study of its visually determined reactions can profitably be made from the standpoints of both psychology and physiology. Accordingly, in the present paper a method permitting measurements of threshold capacities for the discrimination of visual detail in the cat is described, and data bearing on its visual acuity in relation to stimulus distance are presented.

II THE CAT'S EYE

Although direct relations cannot be indicated, it is of importance at this time to consider visual acuity and pattern discrimination in the cat with reference to known facts about the anatomical structure and reflex function of its eyes According to Krause (18) and to Zurn (34) the cat and certain other carnivora are the only domestic mammals in possession of a differentiated retinal area which is homologous to the fovea of primate mammals In her summary of the characteristics of the mammalian eye, Vincent (29) describes the cat's eye as possessing a fovea. It is alleged that there is a focalized depression, temporally displaced, which may be said to be an external fovea Ganzer (3) and Chevitz (2) hold there is no area of this sort, while Slonaker (23), who cites Ganzer and Chevitz favorably, comes to no definite conclusion on this debatable point as a result of his own investigations of the mammalian eye

The eye of the cat possesses a tapetum which is unevenly distributed over the retina, but is more clearly defined in the dorsal aspect (Hesse, 11). The optic disc is round and varies a great deal in color among differential animals (Vincent, 29) The relative density of the distribution of the rods and cones of the retina of the cat's eye has been counted by Thieulin (28) As compared to the retinal cells of the dog's eye, those of the cat are said to be more fine and compact. In the cat, there appears to be distributed along the level of the equatorial zone of the optic globe about one cone for every 25 rods It is also said that, on the level with the area centralis, there is a zone which does not contain cones. Measurements of the density of the distribution of the retinal cells within the alleged fovea or within the area centralis are not available to the writer.

Thieulin (28), on the basis of anatomical researches, states that the cat's eye is brachyophthalmic, and Vincent (29) finds that myopia and astigmatism may be present in domesticated animals. It is well known that refraction is much better in the cat than in the dog (Vincent, 29; Thieulin, 28). Vincent cites the values of 1 33006 with a variation of 0.00407 as the refractive index of the lens, and 1.33009 with a variation of 0.00406 for the fluid media.

The average optical opening of the pupil in the cat reaches sixteen millimeters The pupil is round and contracts to a vertical slit as the illumination is increased, permitting a wide range of pupillary opening. According to the measurements made by Gundlach (4), the speed of pupillary reaction is much faster than that in the human eye but slower than in the pigeon In the adjustment to increased illumination, the pupillary reaction, as in most mammals, has been found to consist of two components, a quick preliminary (startle) dilation and recoil constriction followed by a long-latency, active, reflex constriction (Byrne, 1) Preliminary pupillary dilation in the cat, according to the measurements of Byrne, has a latency of approximately 0 04 to 0.06 sec, whereas the latency of the reflex constriction is approximately 0.7 sec.

In the cat, the maximal, angular value of the anatomical, monocular, visual field is approximately 205 degrees, somewhat larger than in the dog, this greater extent of the visual field being associated with a higher angular value of the transparent cornea (Thieulin, 28). As compared to the dog, the optic axes diverge quite a bit less, the available measurements placing this divergence between seven and nine degrees (Vincent, 29). The locating of the eyes at an increased frontal position in the head reflects itself in a greater overlapping of the visual fields, as well as in a greater number of non-crossing fibers at the chiasm than is found in the dog (Brouwer, 1927) It is held by Vincent (29) that unless specific training has been carried out convergence movements of the two eyes cannot be demonstrated, but against this the statement has also been made that most beasts of prey, the cat not excluded, possess convergence fixation of the two eyes in binocular vision (Bartels, 1).

III. Prior Experiments of Visual Acuity in Animals Methods and Results

The comparative study of visual acuity has been successfully carried out with certain species of insects, amphibia, birds, and some infra-human mammals. The methods employed in these investigations have differed widely as regards apparatus, test stimuli, stimulus distance, and brightness level In some cases the stimuli have been made to move, while in others they have been held stationary. Generally, the experimental study of vertebrates has involved some form of selective training technique, but with invertebrates tropistic behavior has been utilized.

In the experiments of Hecht and Wolf (10) with the honey bee a tropistic response to moving stimuli was employed in the investigation of visual acuity in relation to the intensity of illumination. The bee was placed upon an inclined, uniform, glass plate, below which and parallel to which was another plate, containing alternate black and white stripes of equal width The plates were illuminated by diffuse light projected from below. As the animal oriented upward upon the uniform plate the grating was moved sharply to the right or left, which gave rise to a reaction by the bee either to the right or left, depending upon the direction of the movement of the plate Gratings with lines of different width were employed and experiments were carried out over a wide range of intensities The maximum visual acuity of the bee was found to approximate 62 0 min., a value nearly 100 times larger than the visual acuity of the human eye under optimal conditions (Hecht, 8). Wolf (33) confirmed these results on the bee using a modified method. In similar studies, Hecht and Wald (9) secured a maximal value of approximately 556 0 min for the visual acuity of the fruit fly.

The visual acuity of the frog has been investigated by Pasche (21) by means of moving stimuli The animals were required to react to a bar mounted on a moving pendulum, which was hung above an aquarium The limen of discreteness was found to be 29.4 min. under the conditions in which the experiments were carried out In the birds, visual acuity measurements have been made with the chick and pigeon Johnson (13, 14) used a modified Yerkes-

Watson method with the chick and employed two types of test stimuli, one consisting of lines placed in the same direction and of unequal width, the other, lines of different direction and of equal width Experiments with the first method were not so successful in regard to the time required to train the animals in the initial discrimination At a brightness level of 3 85 millilamberts with the second method, the visual acuity of the chick was found to be 4 07 min

Hamilton and Goldstein (6) secured a value of 2 7 min. for the visual acuity of the pigeon in modified form of Lashley's jumping apparatus. Cards bearing alternate black and white lines were employed as test stimuli, and measurements were made with lines of different width at different stimulus distances The maximum visual acuity of the pigeon was found to be at stimulus distances above 66 cm Below stimulus distances of 31 cm, the acuity was decidedly less (3 8 min and above) Gundlach (4) made similar experiments with the homing pigeon, employing a discrimination apparatus in the form of a Y, in which the animals were required to discriminate at a distance of approximately 450 cm. Under an illumination of approximately 14.4 footcandles, two pigeons gave a limen of discreteness of approximately 0 38 to 0.5 min. The test stimuli were alternate black and white stripes drawn on cards.

The comparative visual acuity of the pigmented and albino rat has been investigated by Lashley (19) by means of an apparatus in which the animals jumped from a small pedestal through apertures in an upright panel Cards bearing alternate black and white stripes were employed as test stimuli, and the animals discriminated between the lines on the basis of differences in directions of the stripes. When making a correct response the rat knocked the card bearing the positive stimulus away from the aperture and landed on a shelf behind the panel. Under these conditions, the albino rat gave a visual acuity of approximately 56 min, while that of pigmented animals was demonstrated to be around 26 min.

Few experiments on visual acuity have been carried through to a positive conclusion with the higher infra-primate animals Johnson (13) used a modified Yerkes-Watson apparatus with the dog but was unable to secure differential responses to horizontal and vertical lines. Williams (32), using similar methods, also failed to obtain differential behavior in relation to specific visual patterns. However, Orbelli, as reported by Pavlov (22), has been able to secure thresholds for the discrimination of circles and ellipses with the conditioned salivary reflex, and Karn and Munn (15) have found evidence for the discrimination of an upright and inverted triangle by the dog

The writer (24) has described experiments in which cats were required to respond to circles and triangles of equal area as the absolute size of the figures was reduced. In this study, which was carried out by means of a method which elicited a response to a lever, it was found that the visual capacity of the cat in such discrimination approximates that of the monkey, as investigated by Neet (20), who used an apparatus similar to that employed by Karn and Munn (15) with the dog In addition, Kennedy and the writer (25) have been able to show that the ability of the cat in discriminating a moving from a non-moving cross is far better that that of the rat in differentiating between moving and non-moving stimuli (Hawley and Munn, 7).

Johnson (13, 14), Kluver (17) and Spence (27), using different types of apparatus and different test stimuli, have studied the visual acuity of infra-human primates. Johnson used two procedures with the monkey, as with the chick, and found a visual acuity of 0 95 min. when the discriminative response was based upon differences of direction of alternate black and white stripes. A brightness level of 3.85 millilamberts was employed. Kluver also employed two methods in measuring the visual acuity of the monkey A first method consisted in requiring the animal to reach through the bars of a cage and grasp a thread on the top of an illuminated glass plate, the thread being attached to a food box not located on the glass By varying the size of the thread a liminal line width could be determined In the second method the animal pulled in one of two boxes containing illuminated glass panels on their front sides, on one of which was exhibited a single line in the form of an ink drawing or thread. The animal's performance was better with the second method, since under these conditions a visual acuity of 0.38 min. was secured when the boxes were placed 200 cm. away Spence, using a technique in which the subject obtained food in a container corresponding to a positive stimulus, made comparative measurements of the visual acuity of the chimpanzee, a five-year-old child, and two human adults Line gratings were employed as test stimuli, and measurements were taken at a number of different stimulus distances and brightness levels. At 120 cm. stimulus distance and under an illumination of 3.98 millilamberts, the acuity of the three different types of subjects were respectively 0.47 min., 0.71 min., and 0.49 min.

IV. Present Experiments

1. *Method.* Diagrams 1 and 2 in Figure I represent the experimental conditons employed in the present investigation. Two

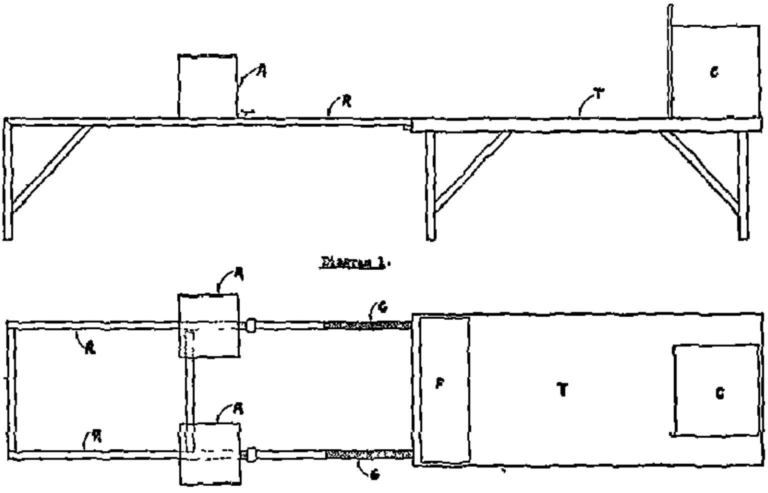

Diagram 1.

Diagram 2

FIGURE 1.
The arrangement of the stimulus boxes for visual acuity experiments. (A), stimulus boxes; (C), restraining cage; (F), galvanized iron flooring; (G), wire grille; (T), runway table; (R) runways.

stimulus boxes (A and A') are rigidly joined together by a cross beam, 5.08 cm. by 5.08 cm. and placed on runways (R and R'), 5.08 wide, which are separated by a distance of 55 cm. The runways extend 215 cm. from the end of the table (T), which has a top surface 76 cm. wide and 182 cm. long. The table and runways are 60 cm. high.

A restraining cage (C), 45.7 cm. square, containing a sliding door on its front side, is located on one end of the runway table. The other end of the table is covered with galvanized iron flooring

(F), which in conjunction with the copper wire grills (G and G'), constitute the electrodes of the electrical circuit giving the shock.

The stimulus boxes (A and A') have been described by the writer, in previous papers (Smith, 24, 25). As arranged for the present experiments, they are illuminated by flood lights, consisting of 200-watt bulbs in polished aluminum reflectors, which are suspended 90 cm. above the end of the runway table Uniform illumination at the front of the boxes is obtained by adjusting the position of the reflectors The walls and ceiling of the experimental room are painted white, as is also a large screen separating the apparatus from the observer

The procedure employed in these experiments is the same as that described in previous studies (Smith, 25, 26) After release from the restraining cage (C) the animal makes a discriminative response at the end of the runway table (T) If the response is correct for that trial, it may approach the stimulus box and obtain food by depressing the small lever Controls for extraneous sensory influences are maintained by uniform procedure, and an additional check on the results is secured by presenting the visual acuity test cards with the lines placed in the same direction The results of the experiments are further validated by quantitative determinations of threshold values for discriminative response, the results of which are presented below

In the apparatus here employed the discrimination distance is controlled by the position of the movable boxes along the elevated runways, as measured from the point where the pathways join the table or from a middle point between the two pathways at the end of the table The former measure was used in the present experiments, since the subjects generally proceeded to a point in front of either of the elevated runways and there made the necessary comparison for the discrimination.

Results Two animals (Laboratory Numbers 5 and 6) with extensive training in other types of discrimination experiments, such as form discrimination, were used in the present study. Subject 5 possessed an undetermined unilateral lesion of the second external convolution of the left hemisphere, made eight months prior to the beginning of the experiments Of the animals available in the laboratory, the two subjects employed were considered to be the most reliable for measurements of the present sort

Three series of experiments were carried out as follows. (*a*) training and testing with alternate black and white lines at 50 cm discrimination distance; (*b*) using single lines[2] 0 64 cm. in width, determination of the point at which the discrimination ceased as the stimulus distance was increased in steps of 10 cm. between 46 and 106 cm.; (*c*) threshold determination of the discrimination of a horizontal and vertical line at distances of 50, 75, 100, and 125 cm

Using 50 cm. discrimination distance, a stable response was established to parallel line drawings, consisting of two cards, 20 32 cm square, on which were ruled parallel black lines 5 08 cm. in width, and separated by an equal distance. A smooth grade of cardboard drawing paper was used and the lines were ruled with India ink. One card, with the lines placed in a vertical plane served as a positive stimulus, while the other, with the lines placed in a horizontal plane, was negative An electrical shock could be given at the beginning of the runway for a response to the horizontal lines. The position of the positive and negative stimuli in the two boxes could be changed by merely rotating the cards 90 degrees.

A series of such grills with line widths ranging from 0 08 cm. to 5.08 cm. was drawn. When the primary discrimination was established the lines were reduced in width by presenting the different grills in the order of the size of the lines.

Both animals learned the primary discrimination (90 per cent response to the vertical line in 20 trials) within four 20 trial periods, and maintained a significant level of response (75 per cent response to the vertical line or above in 20 trials) as the lines were reduced in width. Reduction of the lines was continued until 0.08 cm lines were presented Both animals discriminated above a significant level of response when these grills were presented. Experimentation with the grills was thereafter discontinued because of technical difficulties involved in making alternate black and white lines free from irregularities. Enlarged architect's and the writer's own drawings were found to be defective at reductions beyond 0.08 cm

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[2] The recent arguments by Hecht (8) and Wilcox and Purdy (31) may be said to have raised the question as to whether or not the type of test stimulus used in the present experiments may be considered as valid in measuring visual acuity. The use of a single line, or measures of the "minimum visible", are here understood to give a bona fide representation of visual acuity.

The animals were then presented with a single horizontal and a single vertical line placed at a distance of 46 cm from the choice point. No electrical punishment was employed Again the vertical line was designated as positive, and the two subjects transferred directly from the grills to the single-line situation. The discrimination distance was then increased in steps of 10 cm., keeping the line-width at 0.64 cm.

Using this method, the responses of both animals were significantly influenced when the stimuli were placed at any distance beyond 96 cm Stimulus distances less than this value gave rise to discriminative behavior exceeding a criterion of 75 per cent correct choice of the vertical line in 20 trials, whereas at any distance beyond 96 cm. the accuracy of the responses dropped below this criterion.

A stable response was then established to lines 1.27 cm. in width at a discrimination distance of 50 cm. and the lines thereafter reduced in width until the discrimination broke down. A uniform series of lines was made by India ink drawings on smooth white cardboard, and varied in width from 0 015 cm. to 2 54 cm. The line widths were determined by the aid of a microscope and a fine metal ruler. An additional pair of lines was made by stretching black human hairs across cards of the same sort as those employed in making the drawings The hairs averaged somewhat less than 0.01 cm. When the minimal effective line width had been determined for the stimulus distance of 50 cm , the same procedure was carried out at distances of 75, 100, and 125 cm. respectively.[3]

Table I summarizes the results with respect to 20-trial periods, in the order in which the experiments were carried out. At 50 cm Subject 6 discriminated between the regular series of lines as well as those made by the hairs. Subject 5 gave consistent responses (75 per cent response or above to the vertical line in 20 trials) to lines 0 25 cm in width. It failed on lines below 0.25 cm. in width and with the hair lines. Similar results were obtained when the boxes were placed at 75 cm except that Subject 6 here failed on the 0 01 cm. lines. When a discrimination distance of 100 cm. was employed the

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[3] The brightness values of the test cards at these distances were respectively, 37 8, 39 4, 39 0 and 35 8 apparent footcandles, as measured by the Macbeth illuminometer. The relatively constant illumination at the test cards was obtained by adjusting the position of the light reflectors.

TABLE 1

TRIAL PERIODS AND THE PERCENTAGE OF CORRECT RESPONSES IN THE DISCRIMINATION OF A HORIZONTAL AND VERTICAL LINE AT DIFFERENT DISCRIMINATION DISTANCES

	Subject 5			Subject 6		
Trial periods	Line Width (cm)	Visual Angle (Min)	Percentage correct	Line Width (cm)	Visual Angle (Min)	Percentage correct
50-cm discrimination distance						
1	1 27	88.	100	1 27	88	100
2	.64	44	100	64	44	95
3	32	22	100	.32	22	100
4	16	11	100	16	11	100
5	12	8.23	100	12	8.23	100
6	08	5 5	100	08	5 5	100
7	06	4 13	100	.06	4 13	100
8	05	3 45	90	05	3.45	80
9	04	2 76	100	04	2 76	100
10	025	1 71	75*	025	1 71	90
11	015	1 03	60	025	1 71	90
12	01	69	70	.015	1 03	90
13	025	1 71	100*	015	1 03	80
14	015	1 03	65	01	69	85*
75-cm discrimination distance						
16	2 54	116.	100	2.54	116	100
17	1 27	58 22	100	1 25	58 22	100
18	.64	29.32	100	64	29 32	100
19	32	14.65	100	32	14 65	100
20	16	7 32	90	16	7 32	100
21	12	5 5	100	12	5 5	100
22	.08	3 69	100	.08	3 69	90
23	06	2 76	100	06	2.76	100
24	.05	2 32	90	.05	2.32	95
25	04	1.83	90	04	1 83	90
26	025	1 13	80*	.025	1 13	80
27	025	1 13	85*	015	.69	70
28	015	69	70	01	.45	75*
29	.01	.45	65			
100-cm discrimination distance						
30	.64	22	100	32	11.	75
31	32	11.	90	32	11	70
32	32	11	100	32	11	65
33	32	11.	70	64	22	50
34	32	11.	90	64	22	70
35	16	5 5	85	1 27	44	60
36	16	5.5	90	1 27	44	80

TABLE 1 (continued)

	Subject 5			Subject 6		
Trial periods	Line Width (cm)	Visual Angle (Min)	Percentage correct	Line Width (cm)	Visual Angle (Min.)	Percentage correct
100-cm. discrimination distance						
37	12	4.13	90	1 27	44	85
38	08	2 76	70	1 27	44	100
39	.05	1.71	60	.64	22	90
40	32	11	100	32	11	70
41	16	5.5	80	.32	11.	85
42	16	5 5	90	16	5 5	100
43	12	4 13	85	12	4 13	90
44	08	2 76	60	08	2 76	60
45	12	4 13	85	12	4 13	85
46	12	4 13	85	08	2 76	80
47	.08	2.76	90	06	2 07	75
48	06	2 07	90*	08	2 76	70
49	05	1 71	70	06	2 07	80
50	12	4.13	80	04	1 38	65*
51	08	2 76	75	025	.87	50
52	06	2.07	60*	06	2 07	85
53	.05	1 71	55	05	1 71	80
54				.04	1 38	90*
55				025	87	65
56				.015	.52	60
57				015	52	45
125-cm discrimination distance						
58	64	17 58	55	1.27	34 93	100
59	1.27	34 93	70	64	17.58	95
60	1 27	34 93	85	32	8 8	45
61	1 27	34 93	90	.32	8 8	70
62	64	17 58	100	32	8 8	85
63	.32	8 8	80	16	4.42	90
64	32	8 8	85	.12	3 32	80
65	.16	4 42	40	.08	2.2	85
66	64	17 58	70	06	1 65	85
67	64	17.58	80	.05	1 38	75*
68	64	17.58	85	05	1 38	70*
69	.32	8 8	75	04	1.1	60
70	16	4 42	80	025	68	65
71	.12	3.32	85*	025	68	40
72	08	2 2	60	025	.68	55
73	08	2 2	65			
74	06	1.65	55			

*Indicates liminal line width discriminated sixth subject required retraining with larger lines. The fifth animal discriminated 0.64 cm. lines immediately at this distance. As the lines were reduced in width, the smallest width discriminated by Subject 5 was 0.06 cm., while Subject 6 failed on lines narrower than 0.04 cm. At least two trial periods (40 trials) were carried out with each pair of lines in the range of the animals' thresholds. Lines no greater than 0.12 and 0.06 cm. were selectively responded to by the respective subjects at 125 cm. discrimination distance.

In Table 1 asterisks indicate the critical line widths discriminated by the animals (75 per cent correct response or above to the vertical line in a single series of 20 trials). This line width is employed in calculating the critical visual angle for discriminative response at the different discrimination distances employed. Table 2 summarizes the comparative visual acuity, in terms of the visual angle subtended by the critical line widths for the two animals at the stimulus distances, 50 cm., 75 cm., 100 cm., and 125 cm. Reference to the table will show that marked differences exist between the effective visual angle above and below 100 cm. stimulus distance. The point at which the visual acuity becomes less precise for the two subjects, and particularly Subject 6, corresponds to that where both animals failed consistently in the discrimination of 0.64 cm. lines as the stimulus distance was increased in steps of 10 cm. (second series of experiments). Observation of the animals' behavior by means of motion pictures failed to show any change in the general mode of reaction (head movements and head position) at the different stimulus distances. The variation in the brightness of the test stimuli is not sufficient to explain the observed variation in visual acuity. It is consequently assumed that the differences in visual acuity found represent real differences in the effectiveness of the visual mechanism of the cat at the various stimulus distances employed. Accordingly

TABLE 2

Visual Acuity Expressed in Term of Visual Angle (Minutes) at Four Different Discrimination Distances

Discrimination distance	Subject 5	Subject 6
50 cm.	1.7	.69
75 cm.	1.1	.45
100 cm.	2.1	1.4
125 cm.	3.3	1.4

the conclusion may be drawn that the range of most effective accommodation in the cat, necessary for the discrimination of fine differences in visual detail, probably lies somewhere between 50 and 100 cm Some evidence has been obtained that at stimulus distances *below 75 cm the visual acuity* also becomes less *precise* (see Table 2) The data clearly show, however, that the eye of the cat is better adjusted to visual response at stimulus distances of short range, rather than for long-range vision.

Differences in technique and experimental conditions do not permit accurate comparison of the present results with those secured in prior experiments with other animals Since Kluver (17) used single lines for measuring the visual acuity of the monkey, the procedure of his experiments more closely approximates the methods used in the present study. If this comparison is made, the visual acuity of the cat is found to approximate closely that of the monkey In general, it may be said, notwithstanding the difficulties of the comparison, that the visual acuity of the cat approximates similar measures of the eye of the chick, pigeon, monkey, chimpanzee, and man more than it does that of insects, frogs, or rats This conclusion may also be made even after the fact is taken into account that visual acuity as measured by single lines or test stimuli is approximately five times more precise than when determined by the separation between two or more lines or test stimuli, a method typically used in prior experiments of visual acuity in infra-human animals

The present experiments constitute further evidence for the existence of a highly specialized mechanism for pattern vision in the cat, and tend to emphasize the need for more adequate physiological analysis of visual function in this animal. The measured visual acuity of the cat corresponds more closely to that of animals in possession of a clearly differentiated foveal structure than it does to that of organisms lacking such a retinal area The results of the experiments are validated by the consistencies observed in the behavior of each subject in the different experiments carried out. Furthermore, check experiments carried out at different times as the experiments progressed disclosed the dependence of the responses on the spatial direction of the lines. Lines lying within the critical widths were not discriminated when placed in the same plane, nor were there selective responses to white blank cards inserted in the doors of the discrimination boxes.

V SUMMARY

1. A controlled method is described which permits the determination of the visual acuity of the cat as a function of the distance of the test stimuli from the point at which the animal is required to discriminate.

2. Two highly trained animals learned the discrimination of horizontal and vertical parallel lines within 100 trials at 50 cm discrimination distance and thereafter selectively responded to lines as small as 0 08 cm in width (visual angle 5 5 min.) Threshold limits were not found because of technical difficulties involved in securing grills of the sort that would be free from irregularities in brightness.

3. When single lines 0.64 cm' in width were employed and the discrimination distance progressively increased in steps of 10 cm from 46 to 106 cm., animals consistently failed to respond discriminatively at stimulus distances beyond 96 cm. (visual angle, 22.9 min).

4. With specific training carried out, when necessary, at four different stimulus distances (50, 75, 100, and 125 cm) the critical visual angle was found to vary between 1 1 to 3 3 min. for one animal, and 0.45 to 1.4 min for another. In both cases the lowest critical angle was found to lie at a stimulus distance of 75 cm. However, at 50 and 75 cm. stimulus distances the acuity of vision was approximately the same, there being a marked increase at 100 cm and above. Since the observed differences cannot be accounted for on the basis of observable peculiarities of behavior or in terms of intensity variation of the stimulus cards, it is concluded that accommodation factors are probably important in giving rise to the differences found. Taking this as fact, the efficiency of accommodation in the cat's eye may be said to be at its highest between stimulus distances of 50 and 100 cm.

5. A comparison between these results and those secured by Kluver with the monkey, using comparable methods, indicates no great differences between the visual capacities of the cat and the monkey in the discrimination of single lines.

6. The visual acuity of the cat, as measured in the present experiments, corresponds to that of animals in possession of clearly differentiated fovea rather than to that of animals lacking this

structure This is also true after consideration is given the fact that the present experiments were carried out with single lines, rather than with alternate black and white lines.

7. The results found are validated by the consistency of the performance of the single animals in the different test situations, as well as by uniform procedure and check experiments made during the course of the investigation

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OBSERVATIONS OF DR. ALICE M LEAHY'S "NATURE-NURTURE AND INTELLIGENCE"*[1]

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Dr. Leahy's study of the relation between intelligence and the respective factors, nature and nurture, raises more critical issues than any comparable study which has come to my attention.

Her findings are, briefly, that when age, nationality, and environmental status are held constant there is a significantly higher coefficient of correlation between IQ of children and Otis score and other scores of parents in control groups than between IQ of adopted children and Otis score and other scores of adoptive parents. Adoptions were made at or before six months of age (mean, 2-5 months)

At this age, it is held, there could be no selection on the basis of the intelligence of the child, hence difference in coefficients of correlation reflect hereditary influences or at least influences not attributable to environment Since, in other studies, so far as the present writer can ascertain, no physical trait or combination of physical traits has been found significantly correlated with intelligence when other relevant variables are held constant, Dr. Leahy's results are striking, and, if valid, are certainly very significant; for they suggest that there may be other, as yet unidentified, physical factors which are significantly correlated with intelligence when relevant variables are held constant, and possibly these are inherited. Dr Leahy has kindly sent me the following distribution of mean IQ of children for ranges of Otis score of parents, and I have computed ratio of means.

Mean IQ of children is higher in adoptive than in controls for Otis score 6-55, except for mothers' score 6-15 (four and two observations, respectively), and lower in adoptive than in controls for Otis score 56-75. Mean weighted change is less in adopted than

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[1] *Genet. Psychol Monog*, 1935, 17, 236-308

TABLE 1

RELATION BETWEEN MID-VALUE AT INTERVALS OF PARENTS' OTIS SCORE AND MEAN IQ OF CHILDREN

(Data of Alice M. Leahy)

Mid-parent score	Control Families			Adoptive Families		
	No.	Parents' score / children's score	Mean I.Q of children	No	Parents' score / children's score	Mean I Q of children
6-15	1	12	84 0	3	11	98 7
16-25	5	22	92 2	5	19	106 6
26-35	13	31	99 7	20	28	107 9
36-45	35	39	104 5	32	38	107 4
46-55	38	48	104 2	38	45	113 3
56-65	45	53	113 3	55	53	113 1
66-75	34	56	124 8	24	62	113.7
Mean weighted change		6 13	6 71		8 37	1,63
Fathers' Otis score						
6-15	4	11	92 5	4	9	113 8
16-25	13	22	91 2	10	19	105 2
26-35	21	30	102 8	20	29	105,2
36-45	24	39	103 1	22	36	112,2
46-55	30	47	107 1	31	46	109 4
56-65	35	53	114,5	53	54	111 6
66-75	47	60	118 0	38	61	115 6
Mean weighted change		7 55	4 67		8 16	1 93
Mothers' Otis score						
6-15	2	9	111 0	4	11	99,0
16-25	7	19	108 9	10	19	110,4
26-35	12	30	100 0	24	29	103 8
36-45	36	40	102,5	33	37	110.5
46-55	40	48	104 4	42	45	113 1
56-65	46	53	113,9	49	53	113.5
66-75	46	57	122,8	30	63	111 8
Mean weighted change		6 44	5,41		8 61	1,25

Change at interval is weighted by the formula, $\frac{N_1 N_2}{N_1+N_2}$

in control condition, the proportion is about 1 4 in each series. Proportion of mean IQ of child to mid-Otis score shows greater weighted change in adopted in each series Thus, though mean IQ of child rises more for Otis score levels in controls than in adopted, mean IQ in proportion of Otis score rises more in adopted than in controls, in each series.

TABLE 2
RANGE IN MEAN IQ OF CHILDREN FOR LEVELS OF OTIS SCORE

Otis Score	Controls For Otis 6-75	For Otis 16-75	Adoptive For Otis 6-75	For Otis 16-75
Mid-parent	40.8	32.6	15.0	7.1
Fathers	25.5	26.8	1.8	10.4
Mothers	11.8	13.9	12.8	1.4

Range of means, also, is less in adoptive than in controls.

In each control group mean IQ of children rises fairly regularly *with Otis score of parent, except for mothers' Otis score. In adoptive* groups this is true only of mid-parent Otis score. The fact that mean IQ of adoptive children exceeds that of controls for Otis score 6-15, and is lower for 56-75, suggests a differential factor in control and adoptive children. This factor may be assumed to be due to differential in inherent ability, or differential in environmental status, or selection. If there is differential in inherent ability, this might account for the difference in distribution of means, assuming no selective factor, by a chance distribution of adopted children with regard to Otis score of adoptive parents. We would then expect a smaller range of mean IQ in adoptive children than in controls, higher relative IQ in lower brackets of Otis score, low relative IQ at higher levels of Otis score. This is the actual distribution. Again, differential in mean IQ might result from selection by placing agency or adoptive parent, and such selection might give the above type of distribution. Assuming that environmental factors would act similarly on the two groups of children, adoptive and controls, the difference in distribution of IQ would then be referable, in part, to selection. It seems to me that a decision of the possibility of selecting on the basis of intelligence children who are less than six months of age can be answered only empirically, and I do not know of any crucial experiments. In my ignorance it seems to me a possibility, because of certain recognizable stigmata of very low ability (some types of idiocy). At present, so far as I know, the probability is that selection can be made by way of elimination of some low types of IQ, and so influence the value of the mean IQ of adopted children, and influence particularly the frequencies of IQ at the lower levels. This would imply that adoptive parents with low scores, as well as adoptive parents with high scores, have selective ability, or that agencies select, but select without much regard to IQ of adoptive parent Whatever is responsible for the differential, there is, as a matter of fact, a predominance of control children in the lower ranges of IQ Thus for range 75-105 of IQ the distribution is lopsided, and likewise for upper range, but the differential in frequency is not reversed at upper and lower levels, as one would expect it to be.

TABLE 3

Frequency Distribution of Children's IQ at Lower Levels and at Higher Levels

Range of IQ	No adopted	No. control	Adopted in percentage of controls
		Lower levels	
75-79	1	2	
80-84	0	7	
85-89	10	5	
90-94	6	17	
95-99	21	24	
100-104	23	26	
75-84	1	9	11
75-89	11	14	79
75-94	17	31	55
75-99	38	55	69
75-104	61	81	75
		Upper levels	
164-160	0	2	
159-155	1	1	
154-150	0	0	
149-145	1	2	
144-140	2	0	
139-135	1	6	
134-130	6	7	
129-125	11	19	
164-155	1	3	33
164-145	2	5	40
164-140	4	5	80
164-135	5	11	45
164-130	11	18	61
164-125	22	37	59

Thus controls have higher frequencies both at upper levels and lower levels of IQ. If there was no selection, it is difficult to account for this almost uniformly lower frequency of adopted children at both upper and lower levels of IQ, a ratio of about 2·3 for upper levels, 164-125, and about 3·4 for range 75-104, at lower levels. It is in the lower-upper and middle ranges of IQ, from 105-124, that the frequency of adopted exceeds that of controls. It is obvious that correlation technique will not answer the problem of selection, and equally obvious that selection will affect the coefficient of correlation; for it will disturb certain correspondences in variabilities which would exist if selection were not introduced, or introduce them where they did not exist, or both One wonders, too, about the possible effect of adoptive parent attitude toward adopted child, and of the attitude of the latter toward adoptive parent, and whether the influence of attitude, if such exists, would be spread equally throughout the range of parents' Otis score. A statement by Dr. Leahy suggests that there is sometimes a special attitude of adoptive parent toward adopted child, and perhaps of adopted child toward adoptive parent: "The reasons offered by those parents who refused their cooperation were the following: a fear that the knowledge of adoption would reach the child, child sensitive about adoption."

TABLE 4
FREQUENCY DISTRIBUTION OF ENVIRONMENTAL STATUS SCORE OF ADOPTIVE HOMES AND CONTROL HOMES

Environmental status score	Adopted	Controls	Adopted in percentage of controls
	Upper levels		
239-225	8	0	
224-210	18	8	
209-195	15	13	
194-180	16	21	
239-210	16	8	200
239-195	31	21	148
239-180	47	44	112
	Lower levels		
0-14	0	6	
15-29	1	8	
30-44	2	11	
45-59	7	11	
60-74	22	20	
75-89	12	16	
0-29	1	14	7
0-44	3	25	12
0-59	10	36	28
0-74	32	56	57
0-89	44	72	61

Let us note, now, the distribution of environmental status score of homes of adopted and of controls

In frequency distribution of environmental status of homes of adopted and controls a differential appears in both lower and upper levels. In upper levels families of adopted have predominance (112 per cent for range 239-180), while in the lower levels environmental status of adopted is less frequent than that of controls (61 per cent for range 0-89). Only in the middle range, 60-209, is equality approximated. Not only is mean environmental status of adopted significantly higher than that of controls (137 9, adopted, 118 7, controls) but the distribution of relative status is significantly different in the two groups, as shown, for example, in the difference in standard deviation (54 3 for adoptive, 59 6 for control) Since we do not have the same kind of distribution of environmental status in the two groups, it follows that the correlations in the two cases are not strictly comparable by product moment correlation (Correction for differences in standard deviation assumes comparable distribution of frequencies, with difference in range) When frequency distribution of environmental status is examined, one finds that for adoptive homes the mean is 137 9, the arithmetic mode is 60-74, geometric mode is about 120. For controls the mean is 118.7, arithmetic mode 180-194, geometric mode about 140 Standard deviation of frequency distribution is 14 3 for adoptive, and 13 7 for controls. The significant fact, of course, is the differential distribution of frequencies in adoptive and control families. It follows, then, that if IQ had identical correlations with environmental status in adoptive and control children when the frequency distribution of environmental status was the same in the two groups, there would be a difference in coefficient of correlation when these distributions were changed. As we pointed out, the distributions are significantly different at both upper and lower levels Inasmuch as the other variables correlated with IQ are themselves (presumably) positively correlated with environmental status (fathers' Otis score, mothers' Otis score, mid-parent Otis score, etc) we may suppose that some degree of the difference in coefficient of correlation of environmental factors with children's IQ, of adopted and controls, is the result of difference in frequency distribution of the respective variables with which children's IQ is correlated

The higher environmental status of adoptive children than that of controls appears also when occupational status of adoptive and control *fathers is held constant.*

TABLE 5

ENVIRONMENTAL STATUS OF CHILDREN, BY OCCUPATION OF CONTROL AND ADOPTIVE FATHER

Occupation *of father*	Control			Adoptive			Adoptive-control	
	No	*IQ*	Envir *status*	*No*	*IQ*	Envir *status*	IQ	Envir. *status*
Professional	40	118.6	180.4	43	112.6	194.6	—6.0	14.2
Business manager	42	117.6	160.7	38	111.6	171.3	—6.0	10.6
Skilled trades	43	106.9	106.3	44	110.6	133.2	3.7	26.7
Semi-skilled	46	101.1	77.6	45	109.4	94.0	8.3	16.4
Unskilled	23	103.1	40.1	24	107.8	74.7	5.7	34.6

Thus environmental status is not held constant when child's IQ is correlated with parent's Otis score and with other variables.

Partial correlations show that correlation of adoptive child's IQ with each of the five variables referring to adoptive home is decreased when true mother's occupation or true mother's education is held constant, *and decreased in two instances and raised in two instances* when true father's occupation is held constant Inasmuch as Otis score of parent is (presumably) positively correlated with occupation and education, this suggests that Otis score of true mother influences correlation coefficient positively in two instances and negatively in two instances Since, however, there is not much effect upon zero order of correlation, the probability is that there would be a low coefficient of correlation between IQ of adopted child and Otis score of adoptive parent if other variables were held constant Presumably the same would apply to control children. As will be seen from Table 1, above, although proportion of mean of children's IQ to *parent Otis score, by intervals, differs in adopted and controls, in* each group there is a high correlation with parent Otis score (mid-value of interval) In fact, in each series these correlations approach unity (values weighted by frequencies). The correlation coefficients are given in Table 6

In the absence of individual values, the above correlations suggest that when child's IQ is expressed as ratio of parent's Otis score there is not much difference between adopted and controls in correlation coefficient Indeed, the coefficients are slightly higher in adopted than in controls This, of course, raises the problem of

TABLE 6

Correlations of $\frac{\text{Parents' Otis Score}}{\text{Mean IQ of Children}}$, by Intervals of Parents' Otis Score, with Mid-Value of Interval of Parents' Otis Score

Variable correlated with (Respective) Parents' Otis score, mid-value / Mean of IQ of children	Adoptive	Controls
Mid-parent Otis score	998	977
Mothers' Otis score	999	.974
Fathers' Otis score	998	997

whether correspondence in variability should be expressed in terms of absolute variability or in terms of relative variability, particularly when there is differential in mean of compared variables or in their respective frequency distribution.

In order to compare correlations in terms of relative variability we converted the $r\,xy$ into $r\,x\frac{y}{x}$, for those correlations for which Dr. Leahy's paper provides data for this computation (mean and standard deviation) Correlations of x with index $\frac{y}{x}$, or i, were computed by the formula

$$r\,x\frac{y}{x} = \frac{r\,xy - (Vx/Vy)}{\sqrt{(1 - r^2\,xy) + [(r\,xy) - (Vx/Vy)]^2}}$$

We computed relative change in x and y variables by the formula $r\,xy\ (Vx/Vy)$ and $r\,xy\ (Vy/Vx)$, which gives percentage change of one variable for 1 per cent change in the other The results are presented in Table 7

IQ shows more lag on other variables in each instance in adopted than in controls. The differential is both absolutely and relatively least in the case of environmental status.

Only in controls is there acceleration of other variables upon IQ of children. Range of both orders of relative regression coefficients is much greater in controls than in adopted.

In all correlations of IQ with index, except in the case of environmental status score, which shows the greatest differential, the coefficients (disregarding signs) are higher in adopted than in controls When, however, environmental status is expressed as proportion of

TABLE 7

RELATIVE REGRESSIONS, Vx/Vy, AND Vy/Vx, IN ADOPTED AND CONTROL CHILDREN, AND CORRELATIONS OF CHILDREN'S IQ (x) WITH $\frac{y}{x}$ (i).

For adopted, in each instance, parent refers to adoptive parent

y variables correlated with *x*	Adopted				Controls			
	r xy	*r xi*	*Vx/Vy*	*Vy/Vx*	*r xy*	*r xi*	*Vx/Vy*	*Vy/Vx*
Education of father	.16	—14	.05	53	.48	.09	19	1 20
Education of mother	.21	—18	.08	.54	50	—.005	25	1 00
Mid-parent Otis score	18	—.24	08	43	60	06	.33	1 08
Mid-parent vocabulary score	34	—37	.15	38	56	—.20	41	.77
Environmental status score	.19	—10	06	65	53	38	.15	1 89

IQ of child, the co-efficient is lower in adopted Variation in relative environmental status, therefore, is accompanied by less change in child's relative IQ in adopted than in controls. This lower coefficient in adoptive suggests that the difference in correlation of IQ *with environmental status* (*r xy*) *is partly the result of the difference* in frequency distribution in environmental status score of adoptive and controls, and of difference in mean values of similar variables in the groups compared. For levels of occupation, correlation of mean IQ of adopted children with mean environmental status score of adoptive father is .983, correlation of mean IQ of adopted children with environmental status score of real father is .961. (The two groups of children, however, are not identical). It would be interesting to see correlations of IQ of adopted child with Otis score of real parent, and, for the same children, with Otis score of adoptive parent, and to know how correlations in control groups are affected by holding relevant variables constant, or at least some of them

In conclusion: The two groups of control and adoptive children studied by Dr Leahy are, it appears, not properly comparable by linear correlation There are different frequency distributions of IQ of children in the two series, and there are *different frequency distributions* of environmental status scores Environmental status, therefore, is not held constant. At present it appears not to be known *whether selection of children* under six months of age might influence IQ of the selected group. The possible effect of the psychological factor, consciousness of adoption, has not been assessed More validly comparable results could be achieved by holding environmental status constant, and by pairing children of the same IQ.

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A COMPARATIVE STUDY OF THE INFLUENCE OF RACE AND LOCALE UPON EMOTIONAL STABILITY OF CHILDREN*[1]

From The Alfred Willson Children's Center, Columbus, Ohio

FRED BROWN

HISTORICAL INTRODUCTION

A comprehensive survey of the literature on racial differences reveals a surprising paucity of studies which deal with the comparative emotional stability of racial groups. Most of the work in this field has consisted chiefly of attempts to establish the existence of racial intellectual differences by the administration of mental tests. The majority of such studies have dealt with negro-white comparisons. Some personality studies of American versus Negro (13) and Indian children (9) have utilized the Downey Will-Temperament test. The validity of results so obtained might seriously be questioned in view of serious criticisms leveled against the instrument by Symonds (19) and others Sunne (17) found no personality differences between whites and negroes by means of the Will-Temperament and Pressy X-O tests. Rating methods are questionable and present difficulties which interfere with the accumulation of reliable results (7). Garth (7) favors the questionnaire method and points out that it has been used hardly at all in racial psychology Darsie (6) tried this approach with Japanese children.

Several recent studies of racial emotionality and personality integration have been based upon analyses of first admissions to State Hospitals for the insane Brill and Karpas (2) conclude that Jews

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[1] I take this opportunity to thank Miss Florence Goldman, social worker at the Welfare Association for Jewish Children of Cleveland, Ohio, Mr Lower Kellogg and Mr John Patchen, graduate students in the department of psychology, Ohio State University, for administering the Inventory in the various schools I also wish to express my appreciation to the principals and teachers who facilitated administration of the Inventories by their wholehearted cooperation

contribute a high percentage of so-called functional forms of insanity to state hospital populations with manic-depressive insanity highest and undifferentiated depression neuroses second. Malzberg (12) found that admissions to the New York Civil State Hospital for 1919-1921 gave a mental disease rate of 44.7 for Jews and 69.2 for non-Jews. A continuation of this study in 1927 revealed rates of 42.3 and 75.5 respectively for these two groups. Malzberg attaches little statistical significance to these differences. Rosenthal (14) states that many factors must be considered in an evaluation of first admissions and concludes that very little of the work so far would stand rigid statistical analysis.

The questionnaire method has been used too infrequently to offer data either for or against the thesis of race differences. Sward and Friedman (18) studied 625 adult Jews (high school and college students and parents) with an equal number of non-Jews on the Bernreuter personal inventory and the Heidbreder introversion-inferiority questionnaire. Neurosis and inferiority scores of the Jewish group exceeded the mean of the non-Jewish group about 60 per cent toward the unfavorable direction. Leydesdorff (11) administered a questionnaire to Jews and non-Jews in Holland and presents the following figures:

	Percentage Jews	Percentage non-Jews
Emotionally inclined	63.8	52.6
Quickly offended	52.9	43.5
Good natured	38.6	52.6
Critical temperament	53.4	38.4
Anxious and suspicious	41.0	30.9

The conclusion is reached that Jews are more nervous, sentimental, and passionate than non-Jews. Studies emanating from Germany are obviously unreliable under the present regime.

While some attempts have been made to determine whether differences in emotional stability exist among adults there have been virtually no such studies on children. The value of adult studies is dubious, especially when comparisons are made between a habitat-dominating and a subordinate group. In such cases differences in favor of the former group might be anticipated in view of the greater degree of social and economic security enjoyed by members of a dominant group. Race prejudice and discriminatory attitudes are not so obvious to the child of a minority group parent, hence racial differences, if they exist, should more properly be sought among children.

The reason for this seeming neglect of such an important phase of race psychology appears to have been due to a lack of reliable personality inventories. The pessimistic outlook with regard to inventories for children below the high-school level is clearly expressed by Symonds (19) Those already in existence were not sufficiently valid or reliable for research purposes (3). Finally, the rapid development of intelligence tests and the emphasis placed upon the relationship between intelligence and adjustment seemed to promise more fruitful results than seemed possible by means of a questionnaire. The statistical reliability of the data so secured appeared to offer a greater assurance of meaning and truth-value The significant factor of adjustment and emotional stability with regard to social usefulness is becoming more apparent, so that a decrease in studies of intellectual and an increase in those dealing with personality differences might be anticipated. The present study is an attempt to study the problem of racial emotional differences of children by means of a personality inventory.

THE PERSONALITY INVENTORY

The Brown Personality Inventory has been fully discussed in a previous publication (3) Its use in the present study deviated in no way from the technique previously outlined The data, however, were treated differently. Instead of utilizing gross scores the inventory was divided into five separate categories representing the following divisions.

Physical symptoms	27 items
Anxiety or insecurity	19 items
Home adjustment	13 items
School adjustment	5 items
Irritability or sensitiveness	8 items

Eight miscellaneous items were not included in this classification.

THE GROUP

The inventory was administered to 1647 children between the ages of nine and 15 years This group was not the same as that which was used for the standardization of the inventory (19), although reliabilities calculated for two separate groups by means of

TABLE 1

AGE, GRADE, AND SEX DISTRIBUTIONS OF GROUPS STUDIED

Group	No	Age									Sex		Grade				
		8	9	10	11	12	13	14	15	16	M	F	5	6	7	8	9
1 Cleveland Gentile (high)	100			1	14	12	31	25	16	1	50	50		20	17	24	39
2 Cleveland Jewish (high)	100			5	31	13	16	23	11	1	45	55		38	10	20	32
3 Foreign rural (low)	89			9	17	23	15	17	8		46	43	18	23	22	26	
4 American rural (low)	76		2	10	17	16	19	4	4	4	37	39	27	19	21	9	
5 Columbus (low)	100				2	16	35	28	14	5	42	58			56	44	
6. Columbus (middle)	100	1	2	34	41	17	4	1			52	48	47	53			
7 Columbus (high)	100		2	39	46	11	2				50	50	68	32			
8 Rural (middle)	47			9	12	9	8	9			24	23	12	11	10	14	
Totals	712	1	6	107	190	117	130	107	53	11	346	366	172	196	136	137	71

the "split-half" method yielded coefficients of +.893 and +.920 The coefficient of reliability for the original experimental group was +.896. Table 1 shows the age, grade, and sex distribution of the groups studied. Groups 1, 2, 5, 6, and 7 were reduced to 100 cases each by taking alternate test blanks from each group until that number was reached Groups 3, 4, and 8 included no more than the sum indicated Items in parentheses refer to socio-economic status.

In order to understand fully the significance of our data it will be necessary to provide a brief description of the composition of each group.

Cleveland Gentile: Urban children of high socio-economic status residing in the Cleveland Heights section of Cleveland, Ohio The parents of these children constitute the professional, semi-professional, merchant, and clerical classes The health program of the Cleveland schools is far superior to that of any other section included in this study

Cleveland Jewish: Urban children attending the same school as the above group and similar in composition

Foreign Rural (low): Slovak children of very low socio-economic status residing in the villages and outlying sections of Kipling, Lore City, and Buffalo, Ohio The parents of these children are foreign-born The fathers are employed as coal miners

American Rural (low): Native American (Scotch-Irish descent) rural children of very low socio-economic status attending the same schools as the previous group. Racial origin constitutes the only difference between these two groups

Columbus (low). Urban American children of low socio-economic status living in the business and industrial sections of Columbus, Ohio The parents are chiefly relief clients who normally belong to the unskilled labor class Most of the delinquency cases brought before the court originate from this group

Columbus (middle). Urban American children of average socio-economic status living in the residential section of Columbus, Ohio This section of the city includes several business areas attending to the needs of the university population but has no industrial section The parents belong in the skilled, semi-skilled, and clerical classes

Columbus (high): Urban American children of high socio-economic status residing in a suburban section of Columbus, Ohio. The parents compare favorably with those of the two Cleveland groups.

Rural American (middle). Rural children of high-average socio-economic level. The parents of these children are engaged in agricultural activities. The group was examined in the centralized school at Galloway, Ohio.

RESULTS

Table 2 is arranged according to socio-economic level and gives the average scores and standard deviations for each section of the inventory. According to the data the Jewish and non-Jewish Cleveland groups mark the smallest number of significant items, indicating superior adjustment. The Columbus high group compares favorably with the Cleveland groups. The Rural American of high-average socio-economic level appears to be similar to the Columbus high-average group despite the fact that the former is a rural and the latter an urban group. The American and foreign rural groups make the poorest scores.

TABLE 2
MEAN SCORES ON PERSONALITY INVENTORY ARRANGED ACCORDING TO SOCIO-ECONOMIC STATUS

Group	Physical	Insecurity	School	Home	Irritability
Cleveland	2.87	3.33	1.14	1.84	2.35
non-Jewish	σ3.34	σ2.72	σ1.12	σ2.14	σ1.71
Cleveland	3.69	3.47	1.13	2.26	2.69
Jewish	σ3.36	σ2.94	σ .98	σ2.59	σ1.71
Columbus	3.88	3.88	88	2.23	2.65
(high)	σ3.51	σ2.99	σ1.02	σ2.25	σ1.85
Columbus	4.18	3.93	1.16	1.77	2.62
(middle)	σ3.98	σ3.00	σ1.21	σ1.67	σ1.83
Rural American	4.16	3.35	1.60	2.14	2.81
(middle)	σ2.69	σ2.83	σ1.09	σ1.73	σ1.84
Columbus	6.08	5.17	1.86	2.81	3.29
(low)	σ4.73	σ3.18	σ1.29	σ2.37	σ1.86
American rural	7.60	7.06	2.17	3.81	4.30
(low)	σ5.37	σ3.88	σ1.60	σ2.62	σ1.82
Foreign rural	8.91	7.80	1.79	3.65	4.23
(low)	σ5.77	σ4.15	σ1.41	σ2.55	σ1.97

It is interesting to observe that the scores in general appear to bear a close relationship to the socio-economic status of the groups As adjustment score descends, socio-economic level increases The table also indicates that school and home items are not as important statistically as are those items which belong more properly to the psychoneurotic syndrome The influence of social and economic *differences, however, are nevertheless evident in these categories* The tables which follow show the D/σ_{diff} between the various groups for each part of the inventory.

In Table 3 we observe no significant differences between the Cleveland Jewish and non-Jewish groups (96 chances in 100 of the differences being greater than zero) Since it is customary to regard a critical ratio of less than 3.00 as statistically insignificant, we attach no importance to a D/σ_{diff} below this figure There is no difference between the Columbus high and the Jewish, Cleveland Gentile, Columbus middle, and rural middle groups, even though a rural group is compared with an urban. The Columbus low group is superior to the foreign rural, but the difference between the Columbus native low group and the native rural low group is not as significant as that which marks a comparison between the native and foreign groups on the same level This might indicate a slightly greater degree of homogeneity between the two native groups We find the same to be true of the Cleveland Jewish as compared with the Cleveland and Columbus high non-Jewish The differences are insignificant, however Critical ratios between the low rural groups and the remainder of the groups are all statistically significant. It should be remarked that the lack of statistical significance between the American low rural and the Slovak low rural is as marked as is true when we compare the Cleveland Jewish and non-Jewish groups. This is important when we realize that two different racial or nacio-racial groups are under consideration.

In Table 4 we find that a sense of security, which probably is basic to social adjustment and freedom from neurotic symptoms, corresponds closely to social status. Here, too, we note that the critical ratios are smaller between the two Cleveland groups as well as between those groups which exist on a similar social plane. Both the Jewish and non-Jewish Cleveland groups exhibit slightly larger differences when compared with the foreign rural than with the American rural low group This would indicate a greater similarity

TABLE 3
PHYSICAL SYMPTOMS
(D/σ_{diff})

	American rural	Foreign rural	Cleveland Jewish	Cleveland Gentile	Columbus low	Columbus middle	Columbus high
American rural							
Foreign rural	1.51						
Cleveland Jewish	5.58	7.48					
Cleveland Gentile	6.77	8.68	1.72				
Columbus low	2.25	3.66	4.11	5.54			
Columbus middle	4.66	6.48	94	2.52	3.07		
Columbus high	6.75	7.03	39	02	3.74	56	
Rural middle	4.73	6.55	91	2.52	3.14	03	54

TABLE 4
INSECURITY
(D/σ_{diff})

	American rural	Foreign rural	Cleveland Jewish	Cleveland Gentile	Columbus low	Columbus middle	Columbus high
American rural							
Foreign rural	1.18						
Cleveland Jewish	6.73	8.19					
Cleveland Gentile	7.16	8.65	35				
Columbus low	3.46	4.84	3.29	4.40			
Columbus middle	5.83	7.57	1.09	1.49	2.84		
Columbus high	5.93	7.38	98	1.57	2.96	12	
Rural middle	6.15	7.42	24	04	3.53	1.15	1.05

between the two Cleveland groups in spite of a comparison between two foreign groups (Jewish and Slovak.)

The rural agricultural group is more akin to the two Cleveland and the Columbus middle and high groups than to any other. This would lead us to believe that a sense of insecurity is independent of locale, although we must bear in mind the small number of cases which this group comprises.

Table 5 deals with those responses which may be classed as irritable in nature. By this is meant the ready expenditure of emotional energy in the presence of a relatively normal stimulus pattern The neurotic child is apparently unable to react according to the principle of minimal action (4) and makes "persistent, affective, *non-adjustive reactions to a baffling situation*" (*Hamilton*) *until* such surcharged responses become habitual

The same trends observed in the other categories are also obvious here

Table 6 points to a certain degree of similarity between the two low rural groups and the low urban group The relatively low C.R.'s between the middle rural and the two low rural groups, especially the foreign rural group, might indicate a likeness between rural school environments This is the only instance where these groups are comparable.

Differences in home adjustment are not so greatly in favor of the Jewish group as might have been supposed from the assumed cultural integration of the Jewish home In view of the critical ratios in Table 7 between the Cleveland Jewish and non-Jewish children (approximately 88 chances in 100 of a true difference) we may conclude that the home conditions of socially superior homes are conducive to emotional stability in children It is surprising to find that the critical ratio between the Jewish and Columbus low groups is only 1 57 or 94 chances in 100 whereas that between the Cleveland non-Jewish and the Columbus low group is 3 04 or practical certainty

A study of separate items should reveal the reason for this similarity between the Jewish group, superior in every other respect, and the Columbus low group. The differences between the two low rural groups and the higher groups are all definite. That between the American and foreign low rural groups is practically zero.

An analysis of separate item percentages reveals certain inter-

TABLE 5

IRRITABILITY

(D/σ_{diff})

	American rural	Foreign rural	Cleveland Jewish	Cleveland Gentile	Columbus low	Columbus middle	Columbus high
American rural							
Foreign rural	24						
Cleveland Jewish	5.96	5.70					
Cleveland Gentile	7.22	5.70	1.14				
Columbus low	3.20	3.36	2.38	3.72			
Columbus middle	6.06	5.81	28	1.08	2.57		
Columbus high	5.91	5.66	16	1.20	2.44	12	
Rural middle	4.12	4.21	38	1.46	1.49	59	43

TABLE 6

SCHOOL

(D/σ_{diff})

	American rural	Foreign rural	Cleveland Jewish	Cleveland Gentile	Columbus low	Columbus middle	Columbus high
American rural							
Foreign rural	1.44						
Cleveland Jewish	3.71	3.10					
Cleveland Gentile	4.74	3.00	07				
Columbus low	1.38	30	4.51	4.21			
Columbus middle	4.59	2.80	38	12	3.98		
Columbus high	6.14	4.35	1.77	1.72	5.98	1.78	
Rural middle	2.37	77	2.60	2.40	1.28	2.22	3.85

TABLE 7

HOME

(D/σ_{diff})

	American rural	Foreign rural	Cleveland Jewish	Cleveland Gentile	Columbus low	Columbus middle	Columbus high
American rural							
Foreign rural	.40						
Cleveland Jewish	2.90	3.27					
Cleveland Gentile	5.34	5.28	1.25				
Columbus low	2.61	2.34	1.57	3.04			
Columbus middle	5.93	5.91	1.59	26	3.60		
Columbus high	3.21	4.05	10	1.26	1.78	1.64	
Rural middle	4.27	4.12	33	19	1.96	1.23	27

esting differences between the groups. These differences do not appear to be correlated with race or locale but follow social status. The letter headings follow the same order as that which heads Tables 3 to 7. "H" refers to the rural middle group.

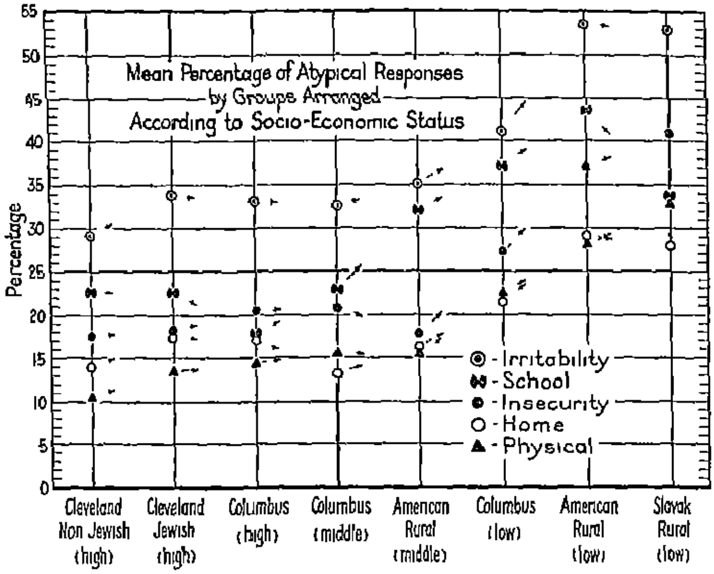

TABLE 8
PERCENTAGE OF ATYPICAL RESPONSES TO EACH ITEM BY ALL GROUPS

Item	Groups A	B	C	D	E	F	G	H
Rationalizing failure	24.7%	29.3%	12%	10%	23%	12%	6%	23%
Being misunderstood	27.3	50.6	23	22	28	24	20	13
Awareness of conflict	53.3	45.0	32	18	39	26	31	32
Negativism	24.7	39.4	14	13	20	9	6	19
Faulty memory	32.5	37.1	11	15	30	25	20	26
Too many demands by others	21.3	29.3	15	18	18	10	12	2
Stuttering	7.9	18.0	6	2	5	3	9	9
Avoidance of competition	16.9	28.1	8	9	24	26	12	5
Compulsion to steal	15.6	20.3	9	10	11	18	11	13
Indecision	75.0	76.4	51	51	73	65	49	62
Anxiety state	67.0	53.9	24	18	50	29	30	34
Fear of imminent disaster	42.9	61.7	6	8	32	15	18	32

TABLE 8 (continued)

Item	Groups A	B	C	D	E	F	G	H
Wish to be different	42.9	43.9	44	44	40	40	39	21
Sensitivity to scolding	86.8	74.1	70	68	75	70	62	72
Bad temper	39.0	28.1	23	29	32	18	24	23
General irritability	55.9	42.7	33	36	35	36	32	30
Feelings easily hurt	57.2	47.2	38	35	52	32	29	28
Reaction to teasing	51.0	52.8	36	31	37	38	43	32
Nervousness	29.9	22.5	7	6	20	6	2	11
Frequent headaches	35.1	37.1	9	4	25	12	10	19
Sluggish circulation	37.7	52.8	13	8	19	8	8	21
Anaesthesias	44.2	45.0	16	10	33	31	39	23
Vertigo	33.8	33.8	11	13	20	9	11	13
Escape mechanism	26.0	32.6	4	2	8	7	3	6
Sudden head pains	61.8	40.5	24	18	48	29	27	28
Enuresis	9.1	4.5	0	3	3	6	4	0
Breathing difficulty	53.3	40.5	18	15	26	25	26	32
Easily angered	33.8	45.0	26	34	34	23	32	28
Fatigue upon arising	36.4	38.3	13	11	29	12	12	15
Anaesthesia of extremities	31.2	40.5	13	6	17	12	3	15
Vomiting after meals	35.1	20.3	5	5	18	21	11	0
Depressive feelings	33.8	52.8	6	7	19	11	5	17
Easily fatigued	36.4	39.4	23	8	32	19	16	28
Nausea at sight of food	32.5	40.5	22	19	18	7	14	13
Paroxysms of coughing or sneezing	31.2	29.3	17	10	15	15	11	15
Motor disturbances	31.2	28.1	11	5	13	20	10	11
Transitory pains	49.4	47.2	25	14	45	26	20	26
Frequent micturation	21.3	29.3	4	6	13	8	12	13
Reaction to bright lights	46.8	55.0	24	26	33	25	34	34
Quickly out of breath	46.8	34.9	32	24	40	36	32	34
Reaction to loud sounds	48.1	58.4	23	26	28	26	18	30
Frequent toothaches	31.2	38.3	3	2	9	13	6	13
Chronic fatigue	10.5	19.2	2	2	6	6	5	0
Motor disturbances	35.1	39.4	15	6	32	16	14	11
Frequent stomach pains	27.3	29.3	14	3	27	11	9	9
Disturbances of sight or hearing	35.1	23.6	5	11	20	16	16	13
Wish to run away from home	19.5	16.9	19	19	25	11	17	11
Frequent parental anger	28.6	34.9	18	10	21	13	12	13
Sib preferred by parents	23.4	31.5	12	12	20	10	12	1
Inability to get along with friends	15.6	15.8	2	2	10	15	10	9

TABLE 8 (continued)

Item	Groups A	B	C	D	E	F	G	H
Maternal strictness	9.1	12.4	7	2	14	5	5	2
Father easily angered	32.5	16.9	18	12	21	11	14	11
Verbal home discipline	64.4	50.6	46	37	54	41	46	57
Parents too strict	15.6	15.8	8	3	16	2	4	2
Death dream of father	33.8	29.3	12	17	15	20	35	23
Death dream of mother	29.9	38.3	16	22	17	15	19	17
Financial worries	61.8	53.9	38	32	43	27	35	21
Parental domination	37.7	57.3	23	12	21	18	18	30
Running away from home	9.1	6.8	1	4	8	1	3	6
Foster-child phantasy	11.7	3.4	7	2	8	1	4	2
Reaction to low grades	42.9	42.7	50	50	59	35	25	26
Recitation difficulty	46.8	31.5	24	32	36	21	15	21
Attentional difficulty	27.3	21.4	12	26	26	17	14	13
Mistakes in school work	75.0	67.4	26	39	54	37	26	51
School too hard	23.4	21.4	1	4	10	5	2	6
Motor disturbance	45.5	49.5	12	8	33	20	14	32
Insomnia	21.3	24.8	5	3	10	6	5	6
Food idiosyncracy	52.0	41.6	41	36	52	37	44	32
Bad dreams and nightmares	48.1	55.0	3	3	27	11	10	15
Feelings of excitement	39.0	61.7	20	9	36	16	23	28
Ashamed of dreams	39.0	32.6	20	11	18	27	20	23
Difficulty falling asleep	53.3	57.3	48	36	36	37	35	21
Waking up at night	45.5	48.4	16	11	36	30	26	25
Anxiety dream	26.0	24.8	9	10	10	15	10	9
Concern with self	40.2	48.4	25	17	21	20	26	28
Emotional perseveration	36.4	33.8	18	19	34	15	32	19
Lack of self-confidence	58.5	61.7	37	38	54	45	41	23
Persistent ideas	65.8	70.8	60	45	54	46	43	45
Anxiety dream	60.5	61.7	21	31	35	40	31	21
Anxiety at bedtime	21.3	24.8	5	3	10	6	5	6

DISCUSSION OF DATA

The critical ratios for various components of the inventory are found to differ somewhat for the Jewish and Cleveland non-Jewish groups when these are compared with other groups of lower socio-economic status. In Table 3 the D/σ_{Diff} between Jewish (low) is 5.58 while for the non-Jewish and American rural it amounts to 6.77. A similar discrepancy is obtained when the two groups are compared with the foreign rural groups. While comparisons between the two different racial groups show no statistical significance, nevertheless, the slight degree of homogeneity between the foreign groups might indicate the presence of racial-social factor, i e, a response tendency to discriminatory attitudes manifested by the dominant group

A study of Table 8 reveals slight but interesting percentage differences between the Cleveland Jewish and non-Jewish groups According to the table we find that Jewish children are more aware of emotional conflict; suffer slightly more with headaches; are not as easily angered, become much more easily fatigued, have more transitory pains and loss of breath, motor disturbances, and stomach pains; strictness of the home seems more frequent in the Jewish than in the non-Jewish homes. The Jewish children are better able to attend in school, make less mistakes in their school work They are slightly more introspective, have a harder time falling asleep, and are more susceptable to persistent ideas. It should be remembered, however, that these differences are not statistically reliable when the entire Home classification is taken into consideration.

Inspection of the scores made by Slovak and native children of the same social level reveals some significant differences which may be attributed to the fact that many of the Slovak children are bilingual Thus, the foreign child might misinterpret "being misunderstood" as indicating verbal facility Stuttering is found to be more frequent in the Slovak group for a similar reason. Depressive feelings seem to predominate in the Slovak group but the foreign fathers seem to have more control of temper than do the native fathers of the same social level. According to the data there is more parental domination in the Slovak homes; but this may be achieved by an absence of overt effort, since it is probably a part of the culture pattern of the home carried over from the homeland The acceptance of this pattern leads to a smaller number of foster-child phantasies among the Slovak children.

The results of our study indicate that differences in emotional stability between racial-rural-urban groups are not a function of either locale or race but chiefly a matter of socio-economic status. This points to a more serious acceptance and recognition of Arlitt's (1) and Shimberg's (16) emphasis upon social status in establishing race norms. We found no reliable differences between Jewish and non-Jewish children nor between Slovak and Scot-Irish children on the same social plane. Adjustment scores for all categories followed closely the socio-economic ranking. Differences between rural and urban groups might have been inferred in the absence of a rural control group (rural middle) or higher social level. It is significant to observe that comparisons between groups in the absence of controls might have led to very erroneous conclusions.

It was somewhat puzzling at first to account for an apparent inversion with regard to the relationship between adjustment and socio-economic status. A previous study (3) yielded an r of $-.11 \pm .003$ between these two variables, leading to the conclusion that "Neuroticism does not predominate in any particular social group. Situations engendering nervousness may be encountered in any stratum of society." While the latter is undoubtedly true, the former is open to question. It is possible that the Sims Socio-economic Score Card, which was used in the aforementioned study, may have been inadequate to detect those phases of familial integration which are related to emotional adjustment. A more detailed scale which would take cognizance of parental attitudes and other intangible factors in the home might succeed in revealing a higher statistical correlation. Further studies along this line are evidently needed.

It is not surprising that our results demonstrate a connection between socio-economic level and adjustment. When we consider the inferior food, parental intelligence, ignorance of child behavior and needs, economic insecurity, and general squalor of low class homes in comparison with those of higher standards the results become entirely consistent.

SUMMARY

The Brown Personality Inventory was administered to 1647 children of both sexes, ranging in age from nine to 14 years. Of this number 712 were used for the purpose of this study, which endeavored to determine whether differences in race and locale influence emotional adjustment. Scores were secured for five categories: physical symptoms, insecurity, irritability, home, and school. Eight separate groups were compared, including Jewish and non-Jewish children of high socio-economic status; Slovak and native rural children of very low social and economic level; a rural native group of average socio-economic status, and three urban groups of low, middle and high social status. The following results were obtained.

1 No significant difference between the Jewish and non-Jewish groups of the same social level were obtained

2 No differences between Slovak and native rural children on the same social plane were found.

3 Statistically significant differences in emotional adjustment between the Jewish-Gentile and Slovak-native groups definitely favored the former.

4. Statistically significant differences between the rural groups favored the rural agricultural group of superior socio-economic status.

5 The urban group of low socio-economic status closely resembled the two low rural groups, although the difference was slightly lower between the two native groups.

6 Scores for the three Columbus groups were found to follow social level very closely.

7 Analysis of separate items indicated slight differences with regard to physical symptoms and home conditions which favored the Cleveland Gentile group when compared with the Jewish group.

8. No relationship was discovered to exist between emotional adjustment and race or locale. Adjustment proved to be closely related to socio-economic level. The higher the social level of the child the greater seemed to be the probability for emotional stability.

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A COMPARISON OF GENERATIONS IN REGARD TO ATTITUDES TOWARD FEMINISM*[1]

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The purpose of this paper is to attempt a quantitative comparison of attitudes in successive generations in regard to Feminism and to compare the results with the general impression derived from observation and historical evidence. It is often said in disparagement that quantitative methods prove what we already knew before. It should be remembered, however, that quantitative evidence often forces a revision or at least a reconsideration of common sense knowledge Furthermore, if the quantitative evidence is in accordance with intuitive knowledge there is a gain in certitude and in the degree to which relationships may be expressed in precise terms

The comparison of generations to be attempted seeks (1) a comparison of Feminism-Anti-Feminism scores of successive generations as a quantitative index of a possible trend in social attitudes, (2) a comparison of sex discrepancies of attitude in the two generations, (3) an analysis of sex and generation differences in inconsistency of attitude, (4) a specific comparison of attitudes of parents and children with reference to possible channels of parental influence in the transmitting of culture and moulding the attitudes of children.

GENERATION DIFFERENCES IN RELATION TO TREND TOWARD FEMINISM

The instrument used in this investigation was the "Belief-Pattern Scale for Measuring Attitudes Toward Feminism" which has been elsewhere described (3, 4).

Evaluational propositions, Feminist and Anti-Feminist, were prepared according to a partially objective outline of 40 issues and were classified with reference to four Feminist and four Anti-Feminist

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categories by judges. Three forms of the test were made up from items most uniformly classified, each form consisting of 40 Feminist and 40 Anti-Feminist propositions covering the various issues Total and partial scores were computed as the algebraic sum of Feminist (positive) items accepted and Anti-Feminist (negative) items accepted Reliability coefficients ranged from 85 to .94 and sharp discrimination between Feminist and Anti-Feminist groups was made by the scale

The test was administered to winter-quarter, University of Minnesota students, 1933-34, with the request that they have blanks filled out by both parents No vigorous effort was made to influence students and only 29 per cent returned blanks from one or more parents. During the spring quarter more pressure was brought to bear and several check-ups were made. The 272 students taking the test included 178 who obtained returns from one or more parents, the percentage return being, therefore, about 65 per cent. This sample is much more reliable in view of a diminished selection factor.

A preliminary non-specific comparison between 312 female University of Minnesota students and 165 student mothers revealed a mean FA score of 16.0 for the students and 9.9 for the mothers The corresponding mean scores for 241 male University of Minnesota students was 6.7 in contrast to a mean score of 5 1 for 152 fathers It would seem at first glance that a social trend in the direction of more Feministic attitudes is suggested by these figures. While a comparison of generations may be a useful device for measuring social trends, the comparison should be specific between generation members within the same family groups Economic status is thus held fairly constant but age, education, and marital status should also be controlled. A more specific comparison for the spring quarter group previously described is presented in Table 1

It is apparent from Table 1 that the relative size of category scores for the various groups is fairly constant Economic and political scores tend to be uniformly high, although the economic scores are much lower for males than for females. In every case the students' mean score is higher than the mean score of the parents except that the mothers of sons make a slightly higher score than do their male offspring Again it would seem that there is some evidence for a continuation of the nineteenth century trend toward Feminism. Before drawing such a conclusion, however, the reliability of differ-

TABLE 1

MEAN TOTAL AND CATEGORY SCORES FOR SPRING-QUARTER MINNESOTA STUDENT GROUP, YIELDING PARENTAL RETURNS, COMPARED BY SEX WITH MEAN TOTAL AND CATEGORY SCORES FOR PARENTS

Category	107 cases Daughters with maternal data	107 cases Mothers of daughters	93 cases Daughters with paternal data	93 cases of Fathers daughters	58 cases maternal Sons with data	58 cases of Mothers sons	59 cases paternal Sons with data	59 cases Fathers of sons
FAE (Economic)	5.1	3.4	5.0	1.6	1.4	2.4	1.6	0.7
FAD (Domestic)	2.3	1.5	2.1	—0.1	0.0	1.0	0.2	—0.3
FAP (Political-legal)	6.1	5.1	5.5	4.4	4.4	4.3	4.5	3.5
FAC (Conduct-status)	1.6	1.1	1.5	0.4	0.8	0.3	1.1	-0.2
Total FA Score	15.1	11.1	14.1	6.3	6.6	8.0	7.4	3.7

ences of means must be taken into account. In Table 2 the differences of means are presented together with critical ratios.

TABLE 2

RELIABILITY OF *FA* SCORE DIFFERENCES BETWEEN GENERATION GROUPS

Groups compared	*Differences of means*	S. D. differences	Critical ratios
Daughters with maternal data and mothers of daughters	4.0 (15.1-11.1)	1.2	3.4
Daughters with paternal data and fathers of daughters	7.8 (14.1-6.3)	1.2	6.6
Sons with maternal data *and mothers of sons*	1.4 (8.0-6.6)	1.5	0.9
Sons with paternal data and fathers of sons	3.7 (7.4-3.7)	1.8	2.1

A small number of rather highly selected returns are available from a few Temple University students and their parents. The number of cases is too small to make the results very significant. The data *presented in* Table 3 at *least suggest that the results at the* University of Minnesota are not completely atypical.

Before concluding that the greater conservatism of the older generation implied in this study reflects a trend of the times, the factors of age and education should be taken into account. FA scores were available from certain student parents other than the parents of students tested during the spring quarter. For the entire group of 215 student mothers the correlation between FA score and mothers' chronological age was only +.040 S. E. .06. The corresponding correlation for 194 student fathers between FA score and age was +.039 S. E. .072. It is apparent that for the age range covered there is no significant relationship between age and score. For 311 University of Minnesota female students studied in another connection the correlation between FA score and age was +.24 S. E. .05. For 241 male students it was +.47 S. E. .05 (5). Since any tendency that exists is in the direction of an increase in Feminism with age, the less *Feministic attitudes of parents taken as a whole and compared* with offspring can hardly be explained by the greater chronological age of the parents. There remains the possibility that the high score of students may be due to higher educational status, rather than to a social trend, favorable to Feminism. The results of exploratory

TABLE 3*

MEAN TOTAL AND CATEGORY SCORES FOR TEMPLE UNIVERSITY STUDENTS YIELDING PARENTAL RETURNS COMPARED BY SEX WITH MEAN TOTAL AND CATEGORY SCORES FOR PARENTS

Category	13 cases Daughters with maternal data	13 cases Mothers of daughters	12 cases Daughters with paternal data	12 cases Fathers of daughters	14 cases Sons with maternal data	14 cases Mothers of sons	10 cases Sons with paternal data	10 cases Fathers of sons
FAE	5.9	5.6	5.4	2.6	3.0	2.0	1.5	1.5
FAP	6.0	6.2	5.2	3.8	4.8	3.6	4.7	4.6
FAD	3.5	2.1	2.4	—0.1	0.2	1.0	0.1	0.7
FAC	4.1	0.8	3.2	0.1	1.4	1.3	0.8	1.1
Total FA Score	19.5	14.7	16.2	6.4	9.4	7.9	7.1	7.9

*Temple data was obtained through the cooperation of Prof. J. W. Woodard. It is interesting to note that the generation differences in regard to attitudes toward Feminism are similar to those derived from a similar scale constructed to measure attitudes toward religion. For 94 mothers the religiosity score was 13.6 and for 78 fathers 11.5. For 100 female students the mean score was 5.2, and for 111 male students 1.3. See Stone (6) and Kirkpatrick and Stone (7, p. 581).

tabulation relating FA score to parents' schooling are presented in Table 4

TABLE 4

MEAN FA SCORES IN RELATION TO YEARS OF SCHOOLING FOR 354 OUT OF THE TOTAL 377 UNIVERSITY OF MINNESOTA STUDENT PARENTS WHO GAVE COMPLETE DATA IN REGARD TO SCHOOLING

	Number	Years of schooling	Mean FA score
	18	0-4	4.4
	95	5-8	6.5
	124	9-12	8.5
	91	13-16	10.5
	26	17-20	7.1
Total	354		

Table 4 reveals some relationship between schooling and FA score, although the coefficient correlation for the 354 parents is only +.126 S.E. .052.

It seems desirable to make a non-specific comparison comparable to one previously presented, yet considering the educational factor Those parents who have had over 12 years of schooling were compared with the college students who had about 14 years of schooling. The results are presented in Table 5.

TABLE 5

A NON-SPECIFIC COMPARISON OF MEAN FA SCORES OF ALL UNIVERSITY OF MINNESOTA STUDENTS AND MEAN SCORES OF PARENTS OF THOSE STUDENTS WHO OBTAINED COMPLETE PARENTAL RETURNS

(Only parents with over 12 years schooling included)

Group	Number of cases	Mean FA score
Female University of Minnesota students	312	16.0
Student mothers (with over twelve years schooling)	55	12.5
Male University of Minnesota students	241	6.7
Student fathers (with over twelve years schooling)	62	7.3

With this rough control of the educational factor, the differences between generations disappear in the case of males and are substantially reduced in the case of females. The most significant comparison would, of course, be between students and parents of their own sex who had more than 12 years of schooling. This comparison is made in Table 6.

TABLE 6

A COMPARISON OF MEAN FA SCORES OF SPRING-QUARTER UNIVERSITY OF MINNESOTA STUDENT GROUPS YIELDING PARENTAL RETURNS, WITH THE MEAN FA SCORES OF PARENTS HAVING MORE THAN TWELVE YEARS OF SCHOOLING

Group	Number of cases	Mean FA score
Daughters with maternal Data	107	15.1
Mothers of daughters (with over twelve years of schooling)	28	14.3
Mothers of daughters (with less than twelve years of schooling)	69	10.5
Parental data lacking	10	
Daughters with paternal data	93	14.1
Fathers of daughters (with over twelve years schooling)	34	7.9
Fathers of daughters (with less than twelve years schooling)	53	5.3
Parental data lacking	6	
Sons with maternal data	58	6.6
Mothers of sons (with over twelve years schooling)	14	9.9
Mothers of sons (with less than twelve years schooling)	38	7.2
Parental data lacking	6	
Sons with paternal data	59	7.4
Fathers of sons (with over twelve years schooling)	14	6.5
Fathers of sons (with less than twelve years schooling)	45	2.8
Parental data lacking	0	

It is apparent from Table 6 that there is no significant tendency for the younger generation to be more Feministic in their attitudes than their parents of the same sex when the educational factor is held constant The fact that sons make an average score .9 greater than their fathers has no statistical significance There is no evidence here that the nineteenth century trend toward Feminism has continued in recent decades, although it is conceivable that the influence of generation differences in marital status conceals a real trend. There is the possibility of more or less qualitative differences in regard to the endorsement of particular items. Below are given five propositions, arranged in the order according to the degree of difference in acceptance tendency as between daughters and mothers. The percentage acceptance is indicated in each case.

TABLE 7

PROPOSITIONS IN ORDER OF DIFFERENTIAL ACCEPTABILITY TO 112 FEMALE STUDENTS OBTAINING RETURNS FROM ONE OR MORE PARENTS AND TO *165 MOTHERS OF STUDENTS*

Proposition	Percentage acceptance students	Percentage acceptance mothers
No. 8. AE "The influx of women into the business world in direct competition with men should be discouraged"	13	45
No 9 FE "The relative amounts of time and energy devoted to household duties on the one hand and to a career on the other should be determined by personal desires *and* interests rather than by sex"	86	56
No 67. FP "The working wife who claims economic equality has no more right to alimony from her husband than he has *right to* alimony from her"	79	55
No 51. FP "There is no valid reason why women should take the nationality *of their* husbands upon marriage"	76	53
No. 16. AE "A woman who continues to work outside the home after marriage is shirking her fundamental duty to *home and children*"	34	56

It is possible that these differences between females of two generations, chiefly on economic interests, might be altered if the size of sample permitted a meaningful specific comparison, with education held more constant.

A similar comparison may be made for the male members of successive generations. The comparison is presented in Table 8.

TABLE 8
PROPOSITIONS IN ORDER OF DIFFERENTIAL ACCEPTABILITY TO 66 MALE STUDENTS OBTAINING RETURNS FROM ONE OR MORE PARENTS AND TO 152 FATHERS OF STUDENTS

Proposition	Percentage acceptance students	Percentage acceptance fathers
No 67. FP "The working wife who claims economic equality has no more right to alimony from her husband than he has right to alimony from her"	47	74
No 31. FD "Married women should struggle against enslavement by domestic obligations"	21	47
No 35 FP "A father has no more right to the earnings of offspring than does the mother."	53	78
No 2. AD "As head of the household the father should have final authority over his children"	23	47
No. 51 FP "There is no valid reason why women should take the nationality of their husbands upon marriage"	71	49

The comparison of males reveals striking differences in regard to three political-legal and two domestic issues, in contrast to the differences between females which involved three economic and two political-legal issues. Both male and female generation members differed in the acceptability of the same two political-legal propositions. It would seem, however, that any difference in attitude which may exist between members of successive generations is general rather than specific for some category of issues.

RELATIVE SEX DIFFERENCES IN SUCCESSIVE GENERATIONS

There is vast theoretical significance in the relative sex differences in successive generations Is the disagreement between the sexes in regard to the proper status of women increasing or decreasing? Is sex antagonism, in so far as it is related to the status of women, becoming more bitter, or are the members of the younger generation reaching a common ground of agreement in regard to these important issues? If there is greater disagreement between the sexes in the younger generation, additional light is thrown on the trend toward increasing divorce rates.

Harking back to the non-specific generation comparison previously made, we find the mean FA score of 312 female students to be 16.0, while the score of 241 male students is 6.7. The difference between means is 9.3 with an S.E. of difference of only 84. The mean score for 165 student mothers is 10.0 and for 152 student fathers 5.3. The difference is only 4.7 with an S.E. of difference of 1.01. It would seem that there is a tendency for the two sexes in the younger generation to be more at odds than the two sexes in the older generation.

A more specific comparison may be made between parents and their own children. The sex differences in mean score are presented in Table 9 for those groups analyzed in Table 1.

TABLE 9

A COMPARISON OF GENERATIONS IN REGARD TO SEX DIFFERENCES IN MEAN FA SCORES

Group	Difference of means	S.D. of difference	Critical ratio
Daughters with maternal data (107 cases) and sons with maternal data (58 cases)	8.5	1.3	6.3
Mothers of daughters (107 cases and fathers of daughters (93 cases)	4.8	1.3	3.7
Daughters with paternal data (93 cases) and sons with paternal data (59 cases)	6.7	1.5	4.3
Mothers of sons (58 cases) and fathers of sons (59 cases)	4.3	1.5	2.8

It seems justified to present in Tables 10-11 a comparison between the propositions on which sons and daughters differ most widely and the propositions upon which the fathers and mothers differ most widely.

It is apparent from the preceding tables that the parents differ in regard to a somewhat greater variety of items. It is also to be noted that the percentage disagreement for the younger generation tends to be somewhat greater than for the parental generation.

Another way of describing differential sex differences between the two generations is to work out rank order correlations between the percentage acceptances by males and females in each generation. The

TABLE 10

PROPOSITIONS IN ORDER OF DIFFERENTIAL ACCEPTABILITY TO 112 FEMALE STUDENTS OBTAINING PARENTAL RETURNS AND 66 MALE STUDENTS OBTAINING PARENTAL RETURNS

Proposition	Percentage acceptance female students	Percentage acceptance male students
No 9 FE "The relative amounts of time and energy devoted to household duties on the one hand and to a career on the other should be determined by personal desires and interests rather than by sex."	86	44
No 35 FP "A father has no more right to the earnings of offspring than does the mother."	91	53
No 43 FP "To deny mothers the right to equal guardianship of their children is to perpetuate *a ridiculous inequality*"	87	49
No 67 FP "The working wife who claims economic equality has no more right to alimony from her husband than he has right to alimony from her"	79	47
No 8 AE "The influx of women into the business world in direct competition with men should be discourage"	13	43

rho between the percentages of the 165 mothers accepting the various propositions and the percentages of the 152 fathers accepting the propositions proved to be 90 The corresponding *rho* between the percentages of 112 daughters accepting the various propositions and the percentages of 66 sons proved to be only 84 A certain convergence of evidence points to the conclusion that the sex disagreement for the younger generation is greater than the disagreement for the parental generation

TABLE 11

Propositions in Order of Differential Acceptability of 165 Student Mothers and to 152 Student Fathers

Proposition	Percentage acceptance mothers	Percentage acceptance fathers
No. 2 AD "As head of the household the father should have final authority over his children"	21	47
No. 50 AD "A man has the right to insist that his wife accept his view as to what can or can not be afforded."	34	57
No. 32 AE "Far too much money is wasted on vocational and professional training for women"	6	28
No. 12 AC "Women should be guided by men's views of decency in dress"	17	38
No. 22 AP "The husband should be regarded as the legal representative of the family group in all matters of law."	51	71

GENERATION COMPARISON OF ATTITUDE INCONSISTENCY

In a previous article a description was given of a so-called general inconsistency ratio which was worked out as an index of the tendency to check both Feminist and Anti-Feminist propositions in a particular category (1). The results of the comparison with the aid of this index of inconsistency is presented in Table 12.

TABLE 12

A Comparison of Mean General Inconsistency Ratios of Spring Quarter Student and Parent Group

Group	No. of cases	Mean G I R
Daughter with maternal data	107	29
Mothers of daughters	107	36
Daughters with paternal data	93	29
Fathers of daughters	93	39
Sons with maternal data	58	39
Mothers of sons	58	.41
Sons with paternal data	59	.38
Fathers of sons	59	.44

Table 12 shows a tendency for the older generation groups to be more inconsistent. In view of the greater inconsistency of the males, the comparison of generation groups of the same sex is most significant. When a less specific comparison is made, involving a larger number of cases, the same tendency persists. In Table 13 all of the University of Minnesota students are compared by sex with the parental groups.

TABLE 13

COMPARISON OF MEAN G I R. DIFFERENCES OF 312 FEMALE STUDENTS AND 165 MOTHERS AND OF 241 MALE STUDENTS AND 152 FATHERS

Group	G.I R difference	S D of difference	Critical ratio
Female U of M students (G.I R .26) and mothers (G I R 38)	12	018	6 67
Male U. of M. students (G I R 36) and fathers (G I R .41)	.05	019	2 63
Female U. of M students (G I R .26) and male U of M students (G.I R 36)	10	.016	6 25
Mothers (G I R 38) and Fathers (G I R 41)	03	021	1 44

It is clear from Table 13 that the parental groups tend to have significantly higher mean G I. R's It also seems to be true that the sex differences in inconsistency tend to be greater in the younger generation.

A distinction can be made between general attitude inconsistency and issue inconsistency (2). An issue inconsistency ratio (I I. R) is the proportion of propositions dealing with the same issues which are checked in both the Feminist and Anti-Feminist version It *is almost logically inconsistent to check both* No 1 FE (*Women have* the right to compete with men in every sphere of economic activity) and No. 8 AE (The influx of women into the business world in direct competition with men should be discouraged). The issue inconsistency ratios (I I R.'s) are presented for the student-parent groups in Table 14

Table 14 reveals rather a substantial tendency on the part of both students and parents to be on both sides of the fence with reference *to a particular issue This may be due to carelessness or to confused* thinking associated with an essentially neutral position The fathers

TABLE 14

MEAN I I R's OF STUDENT GROUPS AS COMPARED WITH PARENT GROUPS

Group	No. of cases	Mean I I. R
Daughters with maternal data	107	23
Mothers of daughters	107	26
Daughters with paternal data	93	24
Fathers of daughters	93	35
Sons with maternal data	58	28
Mothers of sons	58	29
Sons with paternal data	59	27
Fathers of sons	59	36

are especially inconsistent in the sense of checking both Feminist and Anti-Feminist items bearing upon a particular issue This might be expected in view of the likelihood that the fathers were more hurried and indifferent in responding to the request of their *student offspring. An I. I. R of 1.00 would stand for a checking of* both the Feminist and Anti-Feminist items for every issue covered. In view of the sizable ratios found, it is clear that isolated verbalizations must not be taken too seriously. It is striking that there is a good deal of issue inconsistency among students who took the test with great earnestness and whose total test scores yielded high coefficients of reliability.

PARENTAL INFLUENCE ON ATTITUDE FORMATION

No sociological process is more universal than the process by which immaterial culture is transmitted from generation to generation. Investigation in this relatively unworked field meets all the criteria of scientific significance (6). In order to obtain evidence in regard to the relative strength of channels of influence in parent-child relationships, preliminary correlations were worked out between the FA scores of parents and children for a rather heterogeneous collection of families. Winter-quarter cases were included in spite *of the low parental returns, and about a dozen cases obtained from* Temple University. The correlations are presented in order of magnitude in Table 15

A comparison may be made for the parent-student groups previously discussed, which are smaller in size but less selected in view of the better return of parental blanks obtained in the Spring quarter. The correlations are presented in Table 16

TABLE 15

PARENT-CHILD CORRELATIONS OF FA SCORES FOR MINNESOTA AND TEMPLE UNIVERSITY STUDENTS

Variables	No of cases	Coefficient of correlation
Mother Score-Daughter Score	135	+ 38 S E 07
Mother Score-Son Score	90	+ 34 S E 09
Father Score-Daughter Score	115	+ 17 S E. 07
Father Score-Son Score	84	+.07 S E 11

TABLE 16

CORRELATION OF FA SCORES OF SPRING-QUARTER UNIVERSITY OF MINNESOTA STUDENTS AND THE FA SCORES OF PARENTS

Variables	No of cases	Coefficient of correlation
Mother Score-Daughter Score	107	+ 39 S E 08
Mother Score-Son Score	58	+.21 S E 12
Father Score-Daughter Score	93	+ 09 S E. 10
Father Score-Son Score	59	— 10 S E 12

Tables 15 and 16 are in fairly close agreement and show a substantial tendency toward higher mother-child correlation as compared with father-child correlation The low father-son correlations are especially interesting in view of the psychoanalytic theory of latent father-son antagonisms. The results are also in fairly close agreement with the findings of Stone in regard to religious attitudes Her results were obtained with the aid of a "brief pattern" scale and are presented in terms of a rank-order correlation rather than a Pearsonian *r*

TABLE 17

RANK-ORDER CORRELATIONS BETWEEN RELIGIOUS ATTITUDE SCORES OF PARENTS AND OFFSPRING

Variables	No. of cases	Rho
Mother Score-Daughter Score	46	+ 53
Mother Score-Son Score	44	+.62
Father Score-Daughter Score	37	+ 53
Father Score-Son Score	38	+ 33

This is striking agreement in regard to the higher mother-child correlation The problem of interpretation, of course, remains. It is conceivable that the influence upon attitude might have been from child to parent rather than the reverse. There is also the possibility of *reciprocal attitude modification as between generations; also* the possibility of convergence of attitude in the two generations in response to external environmental stimuli. To evaluate these possibilities more precisely a more refined correlation analysis would be necessary By far the most plausible hypothesis is expressed by the saying, "The hand that rocks the cradle rules the world." The channel of cultural influence between mother and child does seem to be especially broad and deep. It is interesting to note that, taking 182 parent pairs related as husband and wife, the correlation between the wife's FA score and the husband's FA score was +.348 S. E 065.

Assuming that the inter-generation correlations reflected for the most part the influence of parents on children, it might be expected that the correlations would be highest for those cases in which the student reported special intimacy during childhood with the parent under consideration. The results are presented in Table 18

Table 18 reenacts the old tragedy of a beautiful hypothesis assault-

TABLE 18

THE RELATION BETWEEN REPORTED INTIMACY OF STUDENTS WITH PARENTS AND CORRELATION BETWEEN STUDENT-PARENT FA SCORES

Variables	No. of cases	Coefficient of correlation
Scores of daughters-most-intimate-with-mothers and mothers' scores	70	+ 319 S E 107
Scores of daughters-equally-intimate with-both-parents and mothers' scores	91	+ 697 S E .053
Scores of daughters-most-intimate-with-mothers and fathers' scores	60	+ 326 S E 115
Scores of daughters-equally-intimate-with-both-parents and fathers' scores	80	+.315 S.E. .100
Scores of sons-most-intimate-with-mothers and mothers' scores	57	+.160 S E .159
Scores of sons-equally-intimate-with-both-parents and mothers' scores	47	+ 294 S E .133
Scores of sons-most-intimate-with-mothers and fathers' scores	45	+.033 S E .133
Scores of sons-equally-intimate-with-both parents and fathers' scores	44	— 108 S.E .149

ed by a gang of brutal facts. In every instance the relative size of coefficients of correlation is the opposite of what would be expected from the hypothesis Reported intimacy with a parent implies a lower correlation of student score with that parent's score than when equal intimacy with both parents is reported This fact illustrates the necessity for interpreting statistical data from the point of view of the entire configuration There seems to be a concealed relationship which is responsible for the results It is probable that equal intimacy *with both parents is associated with a more Feministic and less* patriarchal family tradition This perhaps permits a more flexible and more personal process of attitude formation For example, where daughters are equally intimate with both parents it is likely that the mother is freer to impress her views upon her daughter than in a patriarchal family where the mother is more intimate with her daughter and yet relatively lacking in authority. The same would probably be true in the case of sons whose scores correlate more highly with those of the mother when there is equal intimacy with both parents Again, in a patriarchal family under the stern domination of the father, sons might be forced into greater intimacy with the mothers, and yet the authoritarian position of the father would bring about a higher father-son correlation than when there was equal intimacy with both parents To test fully the hypothesis, causative factors other than intimacy should be held more nearly constant. This intriguing problem awaits further investigation

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LA CONSTRUCTION D'UNE ÉCHELLE DES FORMES DE CROYANCES POUR MESURER LES ATTITUDES VIS-À-VIS DU FÉMINISME

Résumé

On a construit une échelle des formes de croyances pour mesurer les attitudes vis-à-vis du féminisme sur la base des suppositions antérieurement exposées, et dans l'espoir de certains avantages et applications Des propositions évaluatrices, féministes et anti-féministes, ont été préparées selon un résumé en partie objectif de quarante matières en contestation féministes et ont éte classifiés á l'égard de huit catégories par des juges. Trois formes du test ont été formulées des points le plus uniformément classifiés, composées de quarante propositions féministes et de quarante propositions anti-féministes comprenant les diverses matières. On a fait subir le test à des étudiants, à des membres des organisations féministes, et à des prédicateurs luthériens. Puisque l'intensité de la réaction n'a semblé ni constante ni significante selon l'évidence empirique, on a compute les résultats des catégories et les résultats totaux comme les sommes algébriques des points féministes (positifs) acceptés et des points anti-féministes (négatifs) acceptés Les computations des valeurs d'échelle sigma et la comparaison des résultats sur les formes differentes ont semblé justifier ce procédé et la supposition de l'interchangeabilité moyenne des points. Les constances mesurées par le test et le nouveau test et les correlations entre les formes ont donné des coefficients de 0,85 à 0,94 Outre la possession d'une validité inhérente comme reflection de la forme culturale du féminisme, l'échelle a discriminé d'une façon claire entre les feministes et les prédicateurs luthériens et entre les étudiants mâles et femelles

KIRKPATRICK

DER AUFBAU EINER GLAUBENSGEBILDESKALA ZUR MESSUNG DER ANSICHTEN ÜBER DEN FEMINISMUS

(Referat)

Eine Glaubensgebildeskkala zur Messung der Ansichten über den Feminismus wurde auf Grund der früher angegebenen Annahmen aufgestellt und mit der Hoffnung, gewisse Vorteile und Anwendungen zu erreichen Abschätzungsbehauptungen, Feministen und Feministenfeindliche, wurden nach einem teilweise objektiven Grundriss der vierzig Feministenschlüsse vorbereitet und in bezug auf acht Kategorien von Sachverständigen eingeordnet. Drei Formen des Tests bestanden aus Einzelheiten am gleichmässigsten klassifiziert die aus vierzig Feministenbehauptungen und vierzig feministenfeindlichen Behauptungen über die verschiedenen Schlüsse bestanden. Der Test wurde Studenten, Mitgliedern der Feministenvereine, und den lutherische Predigern gegeben Da die Intensität der Reaktion nach empirischer Evidenz unzuverlässig und unbedeutsam erchien, wurden die Kategorien- und Gesamtwerte als aglebraische Summen der Feministeneinzelheiten (positiv) und feministenfeindlichen Einzelheiten (negativ) berechnet Die Berechnungen der Skalawerte und der Vergleich der verschiedenen Werte bei verschiedene Formen schienen dieses Verfahren und die Annahme einer durchschnittlichen Austauschbarkeit der Einzelheiten zu rechtfertigen Die Zuverlässigkeiten, wie sie durch die Prüfungs- und Nachprüfungsmethode

und Zwischenformkorrelationen gemessen wurden, ergaben Koeffizienten von 0,85 bis 0,94 Abgesehen von der anhaftenden Gultigkeit als Widerspiegelung des Kulturgebildes des Feminismus unterschied die Skala scharf zwischen Feministen und lutherischen Predigern und zwischen Studenten und Studentinnen

KIRKPATRICK

AN EVALUATION OF THE USE OF THE ALLPORT ASCENDANCE-SUBMISSION TEST WITH HIGH SCHOOL GIRLS*

From the Department of Psychology of the University of Rochester and Gasport High School

Griffith W Williams and Florence Chamberlain

The Problem

There seems to be no generally accepted definition of the term "personality trait." That it is considered important can hardly be questioned in view of the vast amount of research which is being done in this field Much of this work proceeds on the basis of the hypothesis that it is a generalized tendency in the behavior of the organism. Before this hypothesis can be established it will be necessary to show that there is a genetic development of these tendencies This investigation consists of an attempt to make such a genetic study.

The tendency to be ascendant or submissive in face-to-face social situations is such a "trait" which has yielded to an experimental approach. This is shown in the development of the Allport A-S Reaction Study (2) and its derivatives and the results obtained from their use

This test was developed for use with adult groups and its norms are based on the results obtained from the three upper college classes. It seemed probable that if this adult test were given to a younger group some information might be obtained about the genetic development of this characteristic With this in view, the "Form for Women" was given to a group of girls in high schools and, consequently, younger than those on whom it was standardized.

When the experiment was carried out with this as a basic purpose, it was found that the data had a bearing on several other problems. Among these are the questions (1) whether a progressive tendency toward adult standards of ascendance or submission can be found with reference to particular forms of behavior represented in the

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test (as distinguished from the results of the test as a whole); (2) whether the test can be used with groups younger than those on which it was standardized, (3) the validity of the test when used at these levels; and (4) the relationship between the behavior measured by the test and scholarship as represented by school grades.

SUBJECTS

The subjects were 259 girls in regular attendance at New York State Senior High Schools in a northwestern section of the state These high schools are within 20 miles of one another and are located in villages of less than 2000 in population Thus all of the subjects came from a distinctly rural district, the villages in which the high schools are located being in a successful, fruit-growing section. Their homes can be described as middle-class, comfortable, and typically American homes Not over 5 per cent are of foreign parentage. Furthermore, they are unselected Within the high school groups no distinction was made with reference to intelligence and social standing, the only criterion of selection being attendance at these high schools This provides a homogeneous experimental group which is typical of many others in other parts of the country

The age and grade distribution of the subjects are shown in Table 1. The ages most representative of the particular grades are italicized

TABLE 1

THE AGE-GRADE DISTRIBUTION OF ALL SUBJECTS

	Ages											
	10	11	12	13	14	15	16	17	18	19	20	Total
Junior High	1	3	*7*	*7*	*5*	1	1					25
Freshmen				*7*	*26*	*21*	7	3	1			65
Sophomore					*8*	*26*	*22*	*7*				63
Juniors						6	*23*	*17*	9		1	56
Seniors						2	7	*18*	*14*	6	3	50
Total	1	3	7	14	39	56	60	45	24	6	4	259

Including four doing additional Senior work after graduation

To facilitate the tabulation and interpretation of results with respect to chronological age in subsequent tables, the group has been divided into six age divisions of one year each, the few scattered cases under 13 being included in the 13-year group and those over 18 in the 18-year group. All other cases fall into their normal age groups

MATERIALS AND PROCEDURE

The test used was the "Form for Women" of the Allport A-S Reaction Study. The rating scale was also that used by Allport (2, p. 127) The only minor change made in these printed materials was in the rating scale—the name of the subject to be rated was filled in before the scale was handed to the rater and the first sentence was accordingly changed from "kindly rate the student who gives you this paper" as was done by Allport to "kindly rate this student."

Owing to the difference in the age of this group from that of the upper college levels on which it was standardized, it also became necessary to change the spoken instructions for giving the test in a slight degree They were told to substitute "school" or "high school" wherever the word "college" appeared and similarly "teacher" for "professor" They were also told to raise their hands and wait for the experimenter whenever questions of vocabulary arose. These were answered and the subject then proceeded with the test. This change showed that the description of certain situations presented a distinct language handicap for the first group of subjects to be tested To determine the exact points of difficulty, the remaining 225 subjects were asked to place a question mark by each word or phrase the meaning of which was not clear.

Subsequently, it became evident from the questions and remarks of the subjects that some of the test situations were not within the range of common experience for these girls. As a result, 95 subjects representing the total number in two of the high schools were asked to check those situations which had not been met with sufficient frequency to allow them to give a fair or indicative answer. As this request was not made until the end of the test, it could not affect their test results and consequently, did not necessitate their separate tabulation.

In order to determine the relationship between test scores and scholarship, a group of 95 girls, the total number from one of the other schools, was chosen The estimate of scholarship was based on the average of five monthly marks in the school term, September to January 1932-33, the term immediately preceding the giving of the tests. These grades ranged between 73 and 92.

A group of 65 girls, the total number from one school, was chosen for the determination of the validity of the test as measured by the ratings of fellow students. Six of these girls, selected at random, were given 64 copies of the (slightly modified) rating scale used by the authors of the test. The names of the other girls in the group had to be written on the sheets The raters did not rate themselves The raters had lived in the community for several years and were well acquainted with their fellow-students After the scales had been filled in, her own scales were then arranged by each rater in the rank order of estimated ascendance and submission For example· if a rater indicated that five girls had a "strongly marked tendency to take the active role . . in dealing with her fellows" these were arranged in the order of the estimated strength of this tendency from the most marked to the one most nearly approaching those who only show a "marked tendency to take the active role," etc., these two steps representing the first and second steps in the Allport scale, respectively. The estimates of the girls were obtained without discussion or comparison of ratings among themselves. If a girl was not well known to the rater, her rating was omitted. As all those for whom there were not six complete ratings were omitted, this left a total of 52 girls in this group The rankings given every subject by the six raters were added and the average thus obtained was regarded as the final rank for each girl. The test scores were also converted into ranks and the correlation between the two series then computed by the rank method.

RESULTS

Distribution of Scores. Table 2 shows the distribution of the scores and Figure 1 is a graphical representation of these data.

TABLE 2

DISTRIBUTION OF TEST SCORES N = 259

	Class intervals															
	—30	—25	—20	—15	—10	—5	0	5	10	15	20	25	30	35	40	45
Freq	5	12	22	18	31	33	29	38	21	14	14	11	8	2	1	

The scores ranged between a plus or ascendant score of 42 to a minus or submissive score of 30. The median is 1.5 as compared with an adult median of 15.4. When compared with the adult median, there are 50 cases or 19 per cent of the total with ascendant

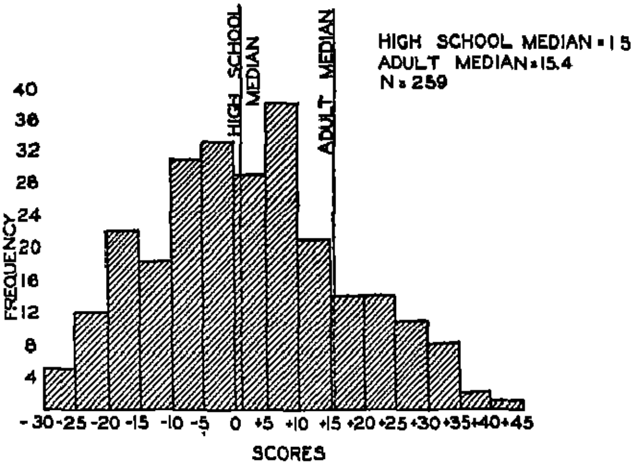

FIGURE 1
THE DISTRIBUTION OF SCORES

scores, the remaining 209 or 81 per cent of the total being submissive.

Tables 3 and 4 show a further distribtution of scores according to school grade and chronological age, respectively. The percentage of ascendant scores in both tables represents the number of subjects obtaining these scores as judged by adult norms.

TABLE 3
THE GRADES, NUMBER OF SUBJECTS, RANGE AND MEDIAN SCORE FOR EACH GRADE AND PERCENTAGE OBTAINING ASCENDANT SCORES

Grade	N	Range	Median score	Percentage ascendant scores
Seniors	50	38 to —25	8.0	40
Juniors	56	42 to —29	5.5	21
Sophomores	63	39 to —30	—1.1	13
Freshmen	65	33 to —28	—5.5	9
Junior High (7-8)	25	29 to —25	—4.5	16

Comparison with Adult Norms. The data have been arranged in Table 5 so as to make it possible to compare them with those on which the test was standardized. In this table the deciles are ar-

TABLE 4

CHRONOLOGICAL AGE, NUMBER AND SUBJECTS, RANGE AND MEDIAN SCORE FOR EACH AGE AND PERCENTAGE OBTAINING ASCENDANT SCORES

C.A	N	Range	Median score	Percentage ascendant scores
18+	34	30 to —25	6 5	29
17	45	34 to —26	1 3	22
16	60	39 to —30	4 0	22
15	56	42 to —24	0 5	20
14	39	29 to —28	—7.5	3
13—	25	31 to —25	—4.5	20

TABLE 5

THE RANGE OF SCORES OF SUBJECTS FOR EACH HIGH SCHOOL DECILE, NUMBER OF SCORES REACHING ADULT STANDARDS FOR EACH DECILE, PERCENTAGE OF TOTAL HIGH SCHOOL SCORES REACHING ADULT STANDARDS FOR EACH DECILE AND THE DIFFERENCE BETWEEN THE OBTAINED PERCENTAGES WITHIN THE DECILES AND THOSE OF ADULTS

Deciles	Range of scores in high school deciles	No of scores within adult decile range	Percentage within adult deciles	Difference from adult percentages
1	+42 to +23	1	0 4	— 9 6
2	+22 to +14	6	2.0	— 8 0
3	+13 to + 9	15	6.0	— 4 0
4	+ 8 to + 5	17	7 0	— 3 0
5	+ 4 to + 1	15	6 0	— 4.0
6	0 to — 4	24	9.0	— 1 0
7	— 5 to — 8	34	13 0	+ 3 0
8	— 9 to —11	39	15 0	+ 5.0
9	—12 to —19	57	22 0	+12 0
10	—20 to —30	51	20.0	+10 0

ranged as they were by the authors of the test, i e., from 1, the most ascendant 10 per cent, through 5 and 6, the middle or average 20 per cent to 10, the most submissive 10 per cent of the adult group

Within the limits of this experiment, the range of scores for the high school deciles can be considered as the norms of this test for use in age and grade limits covered by this experiment The adult norms show that there is a considerably wider distribution of response for the adults than for the adolescents. The extreme adult values range from +59 to —50 while those of the adolescents range from +42 to —30. This would seem to indicate that development towards adult maturity involves an accentuation of both ascendant and submissive tendencies Furthermore, there is a progressive increase in the number of high school students who make scores within the successively submissive deciles This means that the behavior components of the test are those on which this younger group of subjects tend to take a submissive attitude as compared with the adults on whom it was standardized. The same conclusion is substantiated by the percentage of subjects falling within the adult deciles and the difference between the obtained and expected percentages as indicated in the last column of the table. There is a deficiency of nearly 10 per cent in the most ascendant decile and an excess of about 10 per cent in the most submissive decile

Tables 3 and 4, therefore, show the same general tendency, that is, a tendency to develop toward adult standards with an increase in age and progress in school Table 5 shows that for a test that will show a normal distribution for adults the component items are those on which an immature group tends to take a predominantly submissive attitude and development seems to consist of an increase in ascendant responses in these behavior situations

Differentiation of Tendency Toward Ascendance and Submission A further analysis of the data becomes necessary in view of the fact that the extremes of adult behavior as represented by an ascendant score of +59 and a submissive score of —50 are not approached by the experimental group. Development toward adult standards must proceed in both directions. A consideration of the question will be facilitated by the arrangement in Tables 6 and 7, respectively, of those items on which the older years in the experimental group show an increase in ascendant and submissive behavior when compared with the younger years Only those questions showing 5 per cent or more have been selected.

While all of these situations and differences cannot be individually considered to be important or reliable, they serve to indicate the probable direction in which the accentuation of adult tendencies proceeds.

Correlations with Grades and Fellow Students' Estimates. The product-moment correlation between school grades and test scores was found to be 118±.07. This is based on the records of 95 girls with test scores ranging from +38 to —28 and with grades from 73 to 92

The rank-difference correlation between test scores and fellow-

TABLE 6

SITUATIONS SHOWING A PROGRESSIVE TENDENCY TOWARD ASCENDANCY TOGETHER WITH THE PERCENTAGE OF ASCENDANT ANSWERS FOR YEARS 13-14 AND 17-18 RESPECTIVELY, WITH THE DIFFERENCE BETWEEN THE PERCENTAGES

No of *question*	*Situation*	Percentage ascendant answers yrs 13-14	Percentage ascendant answers yrs. 17-18	Percentage difference
1	Not persuaded to try new styles	58	63	5
3	Taking conspicuous seats	3	13	10
5*a*	Soliciting funds	45	61	16
5*b*	No reluctance to solicit	39	49	10
6*b*	Voluntarily starting discussion	50	57	7
9	Remonstrating with person pushing ahead	44	62	18
11	Dissatisfaction at not keeping appointment	2	14	12
14	Not crossing street to avoid meeting	81	91	10
16*a*	Appearing as lecturer or entertainer	13	30	17
17	Willing that friends know they trade at Woolworth's	66	80	14
19*b*	No embarrassment in relinquishing seat	66	75	9
20	Being recognised leader	27	44	17
21*b*	More at ease with other persons	8	19	11
23*b*	No embarrassment at greeting stranger as acquaintance	2	8	6
24*b*	Initiative in opposing chairman	45	58	13
25*a*	Telling owner of losing or breaking tennis racket	77	90	13
26	Questioning erroneous statement	28	34	6
27	Volunteering opinion differing from lecturer	66	77	11
29*a*	Not having "crush"	39	47	8
31	Irritated if not called to recite	45	56	11
32	Thinking teacher talks too much	45	58	13
35	Beginning conversation among strangers	13	20	7

TABLE 7

SITUATIONS SHOWING A PROGRESSIVE TENDENCY TOWARD SUBMISSION TOGETHER WITH THE PERCENTAGE OF SUBMISSIVE ANSWERS FOR YEARS 13-14 AND 17-18 RESPECTIVELY, WITH THE DIFFERENCE BETWEEN THE PERCENTAGES

No of question	Situation	Percentage submissive answers yrs 13-14	Percentage submissive answers yrs 17-18	Percentage difference
2*a*	No attempt to meet important guest	17	27	10
7	Disturbed about false rumor	52	62	10
10	Selfconscious with superiors	81	86	5
12	No initiative at stupid party	73	81	8
21*b*	More at ease with younger persons	5	11	6
34	Difficulty in asking man to go to dance	78	85	7

students' estimates of ascendant-submissive tendencies was found to be 27. This gives a product-moment value of .28± 09, the estimates being based on the combined ratings of six fellow-students for 52 subjects The relatively low correlation may be a function of the smallness of the group, the lack of validity of the test at this level or the incompetence of the raters. It compares favorably, however, with the lower index of validity obtained by the author of the test (2, p 133) where a correlation of .29 was obtained. (A relatively high correlation of .79 was obtained by the authors on a preliminary form of the test when careful instructions in the use of the rating scale were given to the raters)

Difficulties of Language and Situation. It was found that all test items presented a language difficulty of from 3 to 15 per cent of the 225 subjects who cooperated in this part of the work The following are the words and phrases giving the most difficulty—"reluctant," "solicit," "remonstrate," "selfconscious," "superiors," "in the academic or business world," "dictatorial or domineering," "antagonistic," "erroneous," "crush," "stage fright," "lecturer or entertainer," "recognized leader." A good example of the interpretations of high school students of these words is given by the questions asked concerning "stage fright." These included the following—"Does it mean that you get sick? that you faint? that you go blind? that you have to be carried out?" or "Does it mean just being frightened?" This was interpreted as acute nervousness experienced while appearing as an entertainer Similarly the question of what constitutes "entertainment" was raised. Does it mean participation in a "play," "assembly program," "church program, e. g on Children's Day," "singing in duet or chorus," "playing in an orchestra," or a "complete principal-feature role?" This was interpreted to mean any public performance

Six of these items may be made readily usable at this level by rewording. The other five are also included in the list of situations occurring too infrequently to permit the subjects to give a valid answer.

In a group of 95 unselected subjects, 10 or more checked the items listed in Table 8 as having been experienced too infrequently to permit a valid answer

TABLE 8

SITUATIONS UNSUITABLE FOR THE EXPERIMENTAL GROUP BECAUSE OF INFREQUENCY OF CONTACT WITH THEM, TOGETHER WITH THE PERCENTAGE CHECKING THEM (N=95)

No of question	Percentage checking	No of question	Percentage checking
1	32	22*a*	13
2*a*	29	23*a*	12
4*a*	11	24*a*	15
5*a*	43	28	20
6*a*	28	29*a*	20
8	23	29*b*	11
10	13	30	13
15	23	34	33
16*a*	12	35	17
19*a*	34		

While tending to invalidate the test for use at this level of maturity, the difficulty caused by these situations seems to indicate the lines along which the experience of these subjects will extend in its development to the levels of adult behavior An examination of the items, however, does not reveal any consistent tendency or grouping of items. They are, rather, discrete items indicative of a variety of interests.

CONCLUSIONS AND DISCUSSION

While the questions raised at the beginning of this investigation are not fully answered, considerable information is provided by the results which should lead to a conclusion with reference to them. The results also indicate a possible approach to the determination of the genetic development of other factors in adult personality.

The validity of the test at this lower age level has been shown to be comparable to that obtained at the adult level when conditions of measuring it are similar. A possible explanation of this is the fact that most of the items are suitable for both age groups and that those few items found unsuitable for the younger ages are sufficiently varied so as not to invalidate the general results.

For use at this age level, however, it will be necessary to change the wording of those situations which presented a language difficulty, as distinguished from a lack of experience of the situation.

With these limitations, the scores obtained from this group can be considered as establishing new norms for the test at the high school age level. These data are presented in Table 5 Their use should facilitate the work of those who wish to use the test with groups such as freshman women at the time of their entry into college, etc

While the correlation obtained between scores on this test and scholarship corresponds very closely to those previously obtained in similar studies (3, pp 139, 143), it has an additional interest in this case These results show that not only is this trait independent of intelligence at the adult and adolescent levels but also that intelligence is apparently not one of the factors in adolescence which leads to the development of this trait of personality in adulthood The result confirms the hypothesis of the social origin of this trait (1, p. 120).

Information is also provided by these data on the differentiation of the ascendant from the submissive tendency in the behavior of the group It is evident, e g, that the range of variability of these tendencies is considerably less at the adolescent level than it is at the adult level. This probably means that the development of adult attitudes does not proceed from a generally submissive adolescent attitude It seems to indicate that development proceeds from an undifferentiated attitude to a progressive tendency in both of these directions. This substantiates Allport's contention that two tendencies rather than one are represented here (2, p. 121). Maturity apparently involves the development of both tendencies but in different proportions and adjustment requires a submissive as well as an ascendant attitude.

A factor of considerable interest is shown by the fact that both the Junior High and the 13-year chronological age group is somewhat more ascendant than the next higher group in each case This might be due merely to the fact that there are too few cases to be representative but it might also indicate that this school and age level represents a lower limit below which adult standards with respect to the test situations do not function. This suggests the possibility of research to determine the age at which standards of adult behavior begin to constitute a problem for the growing child. Such information is basic to any experimentally determined theory of the nature of personality.

The results show rather clearly that there is a definite genetic development of this trait. It parallels the characteristics of physical development in many respects. There is, e g., a wide range of variability in the development of all age groups. There is, furthermore, considerable difference in the age at which approximate adult levels are attained. There is also a progressive tendency toward adulthood corresponding to progress in chronological age and school advancement All of these have their counterparts in the process of physical development These conclusions are based on the data in Tables 3 and 4

It will be observed that the range for all ages and grades is essentially the same A low score of —25 is found for both extremes of both grade and age. This shows that some remain relatively immature throughout. The high scores in these same groups also remain essentially the same and indicate the early attainment of adult standards by some in the lower groups. Whether these tendencies have been established at the lower ages and remain the same throughout is an important question but it cannot be answered from these data.

That there is a progressive development of this behavior tendency (or trait) seems to be established. It is evident when the data are tabulated for either age or school progress though more marked for the latter. While 50 per cent of adults make ascendant scores, 40 per cent of high school seniors attain that standard and only 29 per cent of those who are 18 years old. The low correlation with ability indicated that this difference is not due to intelligence but is due, in all probability, to their contacts, interests, and general development.

The lack of comparable studies makes it necessary to exercise extreme caution in interpreting these results. While fairly conclusive in themselves, generalizations can only be made when there are several comparable studies of other traits.

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SOME PERSONALITY ADJUSTMENTS OF DEAF CHILDREN IN RELATION TO TWO DIFFERENT FACTORS*

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Deafness is a handicap which produces in general a marked restriction in the environment of its victims. The multifarious sense impressions conveyed to us by meaningful sound are shut out from the experience of this group In this respect the deaf live in greater isolation from the rest of the world than could be achieved for any artificially controlled experimental population. Therefore research into the personality adjustments of such subjects and the relative influence of various environmental factors on them should be of particular interest.

A Personality Inventory for Deaf Children

In personality studies of hearing populations, self-descriptive adjustment inventories have been of considerable value and various instruments are now available for the measurement of different aspects of adjustment in children and adults. However, the characteristic language retardation of the congenitally deaf, and especially of deaf children, offers a serious obstacle to the ready application of such tools of measurement to them. In order to make an objective study of some personality phases of pupils enrolled in residential schools for the deaf, an adjustment inventory was constructed that would be adapted more specifically to the relatively immature thinking habits and limited knowledge of language usage in this group Observations of the language and behavior reactions of deaf children aided in determining the vocabulary of the inventory and the nature of the situations on which its items are brought to bear Also, suitable test items were adapted as far as possible from available personality tests standardized on elementary school pupils.

The inventory consists of 64 items of the multiple choice type,

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dealing for the most part with self-reported attitudes, judgments, and preferences in relation to a variety of every day situations The score in general adjustment is based on the responses to all the items of the test, social adjustment comprises 29 items, school adjustment, 16 items, and home adjustment, 15 items. Sample statements dealing with social adjustment, school adjustment, and home adjustment respectively are shown below

Do you like to play with other children?
— I do not like to play with other children
— I like to play with one or two other children
— I like to play with many children

Are the teachers good to you?
— Sometimes they are good to me
— They are not good to me
— They are very good to me

Are you happy at home?
— I am very happy at home
— Sometimes I am happy at home.
— I am not happy at home

The weighted scoring system was arrived at by application of the Watson adaptation of the McCall-Long Method (3). The additive scoring weights are so arranged that responses to individual items indicative of very good adjustment are given a score of two, responses symptomatic of very poor adjustment a score of zero, and responses of intermediate value a score of one. As a result, high scores point to better adjustment than low scores More detailed data with respect to the construction of the test, as well as its reliability and validity, are presented elsewhere (1). Reliability coefficients obtained from correlating the first and second halves of corresponding test areas and correcting the resulting r by the Spearman-Brown prophecy formula were approximately similar in size whether obtained from deaf or hearing groups For a population of 582 deaf cases, the corrected coefficients amounted to 85 in general adjustment, .68 in social adjustment, .74 in school adjustment, and 61 in home adjustment.

The validity of the test was estimated for hearing cases on the basis of correlation coefficients between test areas of the Personality

Inventory for Deaf Children and the scores from corresponding subtests of two personality inventories standardized on normal elementary school children—Pupil Portraits and Personality Outlines Intercorrelations obtained from the scores of 55 hearing children of slightly above average mentality and in normal classes ranged from .26 to 65 Among the deaf, inventory scores were correlated with teachers' estimates of adjustment for a group of 25 boys and 25 girls. Product-moment coefficients of correlation obtained from the results of boys were 46 in general adjustment, .35 in social adjustment, 68 in school adjustment, and for girls .33 in general adjustment, 30 in social adjustment, and .37 in school adjustment. Since teachers were not familiar with the home relationships of most of their pupils, ratings could not be obtained in this fourth area of adjustment.

THE PROBLEM

In the present study the Personality Inventory for Deaf Children was employed to evaluate the relative influence on adjustment of two types of variations to which pupils of residential schools for the deaf are likely to be subject, i e, the influence of different methods of instruction, including the combined, the manual, and the oral methods, and the effect on adjustment of having one or more other deaf members in the family.

The relative merit of different methods of instruction has never been fully determined, although the vehemence with which controversies on this point were pursued in the past, frequently to the exclusion of many other issues of educational import, has abated somewhat by now The pure oralists usually maintain that only by a complete emphasis on the media of communication employed by persons with normal hearing can the deaf child be brought to approximate mentally and socially the standard of his hearing brother Adherents of the other side hold that the manual alphabet and signs may be also of value in the education of the deaf child and for the development of happy emotional and social adjustments

Among those acquainted with the deaf it is frequently held that deaf children coming from families in which there are other deaf members as well are happier and emotionally better adjusted than children in families where they are the only persons so handicapped

COMPARISON OF INVENTORY SCORES ON BASIS OF METHOD OF INSTRUCTION

The Personality Inventory for Deaf Children was administered to 770 boys and 560 girls in attendance at seven residential schools for the deaf located in Arkansas, Illinois, Indiana, Ohio, Pennsylvania, New York City, and Rochester, New York. At each of these schools from 16 to 58 per cent of the total enrollment was tested, the pupils being drawn from the intermediate and advanced grades. The chronological age range of individual subjects extended from 8 years to 23 years; and the mean age of pupils at the various schools ranged from 15.04 to 17.73 years.

Information with respect to the methods of instruction employed with each subject was obtained from six of the schools But in order to keep the groups taught by the different methods as comparable as possible in other respects, the inventory scores of only those pupils were studied who came from schools in which two or more of the three methods of instruction to be considered here were in use This excluded the population of one purely oral school and the pupils of another at which a fourth method is in use.

It was found that of the 814 cases from the remaining four schools, 35 per cent were reported to be instructed by the oral method—that is, speech, lip reading, and writing were employed as the chief means of communication for educational purposes, 14 per cent were being taught manually, namely, for the most part through the media of signs, the manual alphabet, and writing The remaining 51 per cent were taught by the combined system, representing a combination in varying degrees of the oral and manual methods It is recognized that there is no hard and fast demarcation among these various groups. Pupils reported to be instructed by the oral method at one school may have met with as much experience in finger spelling and signs as pupils classified under the combined method at another school. The likelihood is that the terms "combined," "manual," and "oral" in the absence of more detailed classification vary from school to school

The average personality inventory score of pupils taught by each of these methods together with the standard deviation and the number of cases are presented in Table 1. Orally taught pupils obtain higher mean scores in general adjustment and social adjustment

TABLE 1
INVENTORY SCORE ON THE BASIS OF METHOD OF INSTRUCTION

Adjustment area and group	Oral method N	Oral method Score	Oral method S D	Combined method N	Combined method Score	Combined method S D	Manual method N	Manual method Score	Manual method S D
General adjustment									
Boys	132	106.02	12.28	182	105.85	12.99	80	101.13	13.89
Girls	143	111.95	9.91	147	110.22	9.90	30	106.33	13.42
Social adjustment									
Boys	132	47.58	6.56	182	46.70	6.82	80	44.23	6.48
Girls	143	50.15	5.07	147	48.68	5.35	30	47.05	6.36
School adjustment									
Boys	132	25.22	4.10	182	25.33	4.54	80	23.76	4.60
Girls	143	26.80	3.60	147	26.55	3.46	30	25.47	4.68
Home adjustment									
Boys	132	25.24	3.38	182	25.52	3.22	80	24.26	3.71
Girls	143	26.23	3.13	147	26.67	2.66	30	25.00	3.60

than pupils taught by the combined method, whereas they in turn slightly exceed the average score of manually taught pupils in all four adjustment areas. Table 2 shows the differences resulting from

TABLE 2
COMPARISON OF PERSONALITY INVENTORY SCORE OF PUPILS TAUGHT BY THE ORAL AND MANUAL METHOD

Adjustment area and group	Diff	$S D_{diff}$	$\frac{Diff}{S D_{diff}}$
General adjustment			
Boys	4.89	1.88	2.59
Girls	5.62	2.59	2.17
Social adjustment			
Boys	3.35	0.92	3.64
Girls	3.10	1.24	2.50
School adjustment			
Boys	1.46	0.62	2.35
Girls	1.33	0.91	1.46
Home adjustment			
Boys	0.98	0.51	1.92
Girls	1.23	0.71	1.73

a comparison of the adjustment scores of the oral and manual groups. The data include in each area the difference between the corresponding averages of these groups, the standard error of the difference, and the ratio of the difference to the respective standard error Differences in score throughout are in favor of the orally taught population, are more pronounced in the case of boys than girls, and are largest in both sexes in social adjustment.

If the results are taken at face value, it appears that better adjustment scores tend to be associated with oral rather than manual methods of instruction A more thorough analysis, however, reveals a possibility that differences obtained may be due to a selection of subjects rather than to the effects from methods of instruction. In most schools having more than one method of instruction, pupils who are less intelligent, the least promising in the eyes of their teachers, and the most difficult to handle, are relegated to manual classes. That manually taught pupils in such schools have on the average lower intelligence quotients than pupils in oral or combined classes and that their school achievement is commensurate with their more limited intellectual endowment has been experimentally verified (2).

In connection with a previous study (1) of the validity of the Personality Inventory for Deaf Children, high scores on the inventory were found to be associated not only with more favorable ratings of pupil adjustment by teachers but also with better ratings in school work For instance, of the 770 deaf boys tested, 122 were rated by their teachers as excellent in school work and 208 as poor, with a resulting critical ratio between the mean scores of these two groups of 7.96 in general adjustment and 10 02 in the area of school adjustment Of 560 deaf girls tested, 90 were rated by their teachers as doing excellent school work and 131 as poor, with a resulting critical ratio between the mean scores of the groups of 5 86 in general adjustment and 0 78 in school adjustment. Although critical ratios were smaller for girls than boys, the subjects of both sexes rated as excellent in school work obtained better adjustment scores than those rated poor.

The percentage of pupils rated by their teachers as poor and excellent in school work in connection with the three methods of instruction is shown in Table 3. A larger proportion of boys and girls taught by the manual method are rated as poor in classroom

TABLE 3

TEACHER'S RATING OF PUPILS' SCHOOL ACHIEVEMENT CLASSIFIED BY METHOD OF INSTRUCTION

Method of instruction	Teachers' rating of pupils' school achievement Poor N	 Percentage	 Average N	 Percentage	 Excellent N	 Percentage
Boys						
Combined	51	23	126	58	41	19
Manual	27	39	37	53	6	8
Oral	26	24	62	57	20	19
Total	104	26	225	57	67	17
Girls						
Combined	39	26	88	60	20	14
Manual	15	54	12	43	1	3
Oral	33	23	95	67	14	10
Total	87	27	195	62	35	11

work than pupils taught by either of the other two methods, and conversely a smaller percentage of manually taught pupils receive a rating of excellent

Therefore we should expect to find on the basis of teachers' estimates of school achievement alone a larger number of well-adjusted pupils among orally than manually taught pupils Moreover, if the oral method in and of itself were productive of better adjustment than other methods, then oral schools should have, other things being equal, higher average inventory scores than combined schools Since data for only one purely oral school are available, the evidence on this point cannot be conclusive. Equally high inventory scores were obtained by some of the combined schools and by the oral school. A comparison of the pupil adjustment scores obtained from the one oral school with the mean adjustment scores from the four combined schools, as indicated in Table 4, shows that differences between the scores of schools employing these two methods are less consistent than differences between groups at the combined schools Nor is the presumably poorer language ability of manually trained pupils necessarily responsible for the lower scores. In that event, the average adjustment scores of manually trained girls would probably be below rather than equal to the average of the orally taught boys, and the sex differences found so consistently for this inventory might be likewise disrupted. The conclusion therefore is that manual classes may be expected to contain a slightly larger

TABLE 4

COMPARISON OF MEAN PERSONALITY INVENTORY SCORE OF ORAL AND COMBINED SCHOOLS

Adjustment area and group	N	Score	S.D	Diff	S.D$_{diff}$	Diff / S.D$_{diff}$
General adjustment						
Boys						
Combined	396	104.39	13.20			
Oral	188	106.12	11.35	1.73	1.06	1.63
Girls						
Combined	325	110.53	10.42			
Oral	127	111.98	10.28	1.45	1.08	1.34
Social adjustment						
Boys						
Combined	396	46.61	6.80			
Oral	188	46.57	6.57	0.04	.59	0.07
Girls						
Combined	325	49.21	5.61			
Oral	127	49.27	6.54	0.06	.66	0.09
School adjustment						
Boys						
Combined	396	25.14	4.61			
Oral	188	25.49	3.82	0.35	.36	0.97
Girls						
Combined	325	26.74	3.67			
Oral	127	26.94	3.68	0.20	.39	0.51
Home adjustment						
Boys						
Combined	396	25.62	3.47			
Oral	188	25.79	3.17	0.17	.28	0.61
Girls						
Combined	325	26.67	3.02			
Oral	127	26.50	2.76	0.17	.30	0.57

proportion of pupils with personality difficulties, as indicated by the Personality Inventory for Deaf Children, than oral classes.

ADJUSTMENT SCORES ON THE BASIS OF THE AMOUNT OF DEAFNESS IN THE PUPIL'S FAMILY

The Personality Inventory scores of 1263 pupils for whom information with respect to family background was available were tabulated and averaged for each of the following categories (*a*) pupils reported to have no deaf members in the family, (*b*) pupils with one or more deaf relatives on the side of either one or both parents, (*c*) pupils having one or more deaf siblings, but hearing parents, (*d*) pupils with deaf parents, and possibly with deaf relatives as well. The number of cases in each of these classifications, their average inventory score, and the standard deviation are given in Table 5.

Boys and girls who have deaf members in their family obtain in general better scores than pupils who do not. There is an interesting, although not entirely consistent, tendency for highest average adjustment scores to occur among children who have deaf relatives but no deaf members in their more immediate family. The general tendency runs as follows: the poorest adjustment scores are obtained by children having no deaf members in their family, scores next in size by children having one or more deaf siblings, children with deaf parents obtain the next best scores, and the highest adjustment scores are made by pupils with one or more deaf relatives but hearing parents and siblings.

The results from the comparison of scores of subjects having no deaf members in their family with the scores of subjects having deaf parents are given in Table 6 For both sexes average adjustment scores are in favor of the group with deaf parents.

These findings on adjustment in relation to the presence of more than one case of deafness in a given family confirm the beliefs commonly held about this condition Children from families in which there are also other deaf members appear to be on the average definitely better adjusted than children from families in which there are no other cases of deafness It may be that the deaf child in a "deaf" home is better understood during his preschool life. He is not handicapped by the absolute misunderstanding or by the misdirected sympathy which may be the lot of the deaf child in a home made up entirely of hearing individuals who have never had the experience of living with deaf individuals.

In all of the comparisons made, whether on the basis of method of instruction or amount of deafness in the family, larger critical ratios are obtained for differences between the scores of boys than girls Since this applies also to comparison of scores on the basis of teachers' ratings, the chances are that the Personality Inventory for Deaf Children shows better discrimination between groups of boys than girls

TABLE 5

INVENTORY SCORE ON THE BASIS OF AMOUNT OF DEAFNESS IN THE FAMILY

Adjustment area and group	No deaf members in the family N	Score	S.D.	One or more deaf relatives N	Score	S.D.	One or more deaf siblings N	Score	S.D.	Deaf parents N	Score	S.D.
General adjustment												
Boys	533	103.18	12.94	31	112.23	11.22	128	106.69	11.25	42	110.38	9.69
Girls	346	109.03	11.48	26	112.77	6.52	112	110.75	10.23	45	112.16	10.28
Social adjustment												
Boys	533	45.88	6.83	31	50.27	3.96	128	47.29	6.07	42	48.76	3.64
Girls	346	48.76	6.28	26	51.19	3.96	112	49.51	5.77	45	50.23	5.42
School adjustment												
Boys	533	25.01	4.32	31	26.95	3.28	128	26.10	3.72	42	26.93	3.61
Girls	346	26.82	3.96	26	27.31	3.31	112	27.33	3.49	45	27.41	3.58
Home adjustment												
Boys	533	25.81	3.30	31	26.44	2.14	128	25.97	3.55	42	27.20	2.34
Girls	346	26.85	2.84	26	27.62	2.13	112	26.57	3.48	45	27.28	2.46

TABLE 6

COMPARISON OF INVENTORY SCORE OF SUBJECTS HAVING NO OTHER DEAF MEMBER IN THE FAMILY WITH SCORE OF SUBJECTS HAVING DEAF PARENTS

Adjustment area and group	Diff	S.D_{diff}	$\frac{\text{Diff}}{\text{S D}_{diff}}$
General adjustment			
Boys	7.20	1.59	4.53
Girls	3.13	1.65	1.90
Social adjustment			
Boys	2.88	0.64	4.50
Girls	1.47	0.88	1.67
School adjustment			
Boys	1.92	0.59	3.25
Girls	0.59	0.57	1.04
Home adjustment			
Boys	1.39	0.39	3.56
Girls	0.43	0.40	1.08

SUMMARY

1. In order to make an objective study of some personality adjustments of deaf children in relation to certain factors, an adjustment inventory of the self-descriptive type was constructed that would meet the requirements of this handicapped group. Data with respect to the reliability and validity of the instrument tended to justify the use of this instrument for the measurement of group tendencies in the areas of general adjustment, social adjustment, school adjustment, and home adjustment.

2. The personality inventory scores of 714 pupils enrolled in public residential schools for the deaf were classified and averaged on the basis of the method by which they were being taught including the combined, the manual, and the oral methods. On the basis of inventory scores, pupils taught by the oral method tended to be somewhat better adjusted than manually taught pupils, whereas subjects taught by the combined system occupied an intermediate position. Further analysis suggested that differences in adjustment among these groups might be due to the initial selection of subjects for such classes rather than to the influence of a specific method of instruction.

3. The personality inventory scores of 1263 pupils were classified

and averaged with respect to amount of deafness in each subject's family. With some minor exceptions, the poorest adjustment scores were obtained by subjects having no deaf members in the family, scores next in size by children having one or more deaf siblings, then by children with deaf parents, whereas the highest adjustment scores were obtained by subjects with deaf relatives, but hearing parents and siblings This finding supports the belief commonly held by those acquainted with the deaf, that deaf children coming from families in which there are also other deaf members tend to be better adjusted than cases in families where they are the only member so afflicted

4 The consistently better discrimination shown by the scores of boys than of girls suggests that the Personality Inventory for Deaf Children is a more valid instrument with the former than with the latter

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THE RELATIONSHIP BETWEEN BRAIN LIPIDS AND LEARNING ABILITY OF ALBINO RATS*[1]

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Our knowledge of what definite neural organs or factors account for variations in intelligent behavior such as learning ability is inadequate The findings from more important anatomical studies of the cerebral location of higher mental functions are not conclusive. Bolton (5) decided from his study of the brains of aments and dements that the highest mental processes were the functions of the prefrontal region of the cerebrum. But Hammerberg (11) had reported that cortical cell deficiency in aments existed in many different areas with "no intimation of a greater deficiency in the association areas than in other parts of the cortex" Moreover, Franz (8) reported learning in monkeys after destruction of the frontal lobes This lack of agreement was probably only intensified by the later studies of Bianchi and Feuchtwanger. Bianchi (3) concluded from the results of cortical injury in dogs and monkeys that the highest correlating centers were in the frontal lobes. But Feuchtwanger (7) found in his comparison of 200 cases of frontal lobe lesions with a similar number of cases of lesions in other cerebral areas no evidence that defects of intellect were characteristic of frontal lobe cases. Finally Lashley's (15) extensive studies of the behavioral consequences of lesions in different cerebral areas have definitely challenged if not discredited the theory of localization of higher functions In fact, his theories of mass action and equivalence of function indicate, as he suggests, the necessity for a dynamic theory of brain action The relevant outcome, however, of these outstanding studies remains the same· no definite organ or factor which will

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[1] This was a cooperative study The psychological work was done by O W Alm, of the Department of Education The chemical analyses were made by C H. Whitnah as contribution No 201, Department of Chemistry, Kansas Agricultural Experiment Station

account for individual differences in higher behavioral functions has yet been conclusively indicated. Lashley concludes "There is as yet no clue to the nature of the dynamic forces in nervous activity . . . but their action may be electrical or electrochemical, diffuse or conducted through the nervous net work, continuous or intermittent" (15). This conclusion suggests the possibility that these dynamic forces are highly reactive chemical components.

There are many facts and theories pointing in that direction. The probable importance of chemical components stands out in certain pathological conditions McQuarrie, Manchester and Husted (16) reported that the frequency of epileptic seizures correlates positively with the magnitude of the lecithin-cholesterol ratio in the blood According to their findings the frequency of seizures in epileptics also correlates with the intracellular hydration of the body (very probably of the brain neurons) and with the marked increase in the potassium-sodium elimination ratio produced by pituitary antidiuresis. Koch and Mann (14) reported the destruction of phosphatides in the brain in general paralysis. Pighini (17) reported for this disease an increase in the content of water, protein and cholesterol of the brain with a considerable decrease of phosphatides, especially of unsaturated phosphatides. Koch and Voigtlin (13) reported a marked decrease in cerebrosides in all parts of the central nervous system under the pathological conditions brought on by pellagra

These pathological chemical conditions of brain tissue in mental disease suggest a number of important facts about lipids. The irritability of any tissue is, in general, proportional to its lipid content Nerve tissue is not only conceded to be the most irritable tissue, but, according to Bloor (14) it probably has the highest lipid concentration of any tissue Moreover, the phospholipids of the brain have the highest content of unsaturated fatty acids including arachidonic (4) This high content of unsaturated fatty acids may be especially significant in view of the following observations by Koch and Voigtlin (13): "They (the phospholipids of the neuron) occur largely in the cytoplasm, cell body, and its branches, where they may act as oxygen carriers, as has been suggested by the works of Koch and Mostrom, Fraenkel, and Dimitz, as well as Signorelli", and "The large amount of unsaturated substances with autoxidative properties in nervous tissue would speak more in favor of the view that this tissue possesses a considerable capacity for oxidation. This is brought out by experiments previously described, demonstrating the consumption of large amounts of oxygen by (the phospholipid) kephalin".

These facts about neural lipids may account for the increased consumption of oxygen and increased production of carbon dioxide by active nerve tissue, which has been indicated by different studies on nerve metabolism (9). They need not conflict with Hill's (12) suggestion that the "initial heat" from nerve stimulation may be due to the discharge of the electrical capacity of the nerve. On the importance of lipids for neural activity the findings by Serejski (18), and Whitnah and Cribbett (19) are also significant. Serejski found in the study of brain lipids in dogs that brain lipids are organ specific and are not replaceable by the lipids from other organs. Whitnah and Cribbett found marked individual differences in the brain-lipid content in rats. It is such findings as the foregoing that indicate, perhaps only vaguely in some instances, the need for a psychochemical study such as is reported in this manuscript.

ANIMALS USED

This study began in the late summer of 1933 and continued until the Spring of 1935. The subjects studied were four groups of albino rats from pure Wistar stock. The main facts about these animals are presented in Table 1.

TABLE 1

GENERAL FACTS ABOUT ANIMALS

	Series II	Series III	Series IV	Series V
Number	15	19	35*	41*
Maze	*A* + *B*	*B*	*B*	*B* + *C*
Age at beginning learning				
Maze *A*	100-120 days			
Maze *B*	(followed *A*)	65 days	100 days	106 days
Maze *C*				40-45 days
Age at time of chemical analysis**	125-150 days	90 days	120 days	126 days

*From the original group of 40 in Series IV, 1 bright and 2 dull animals were selected for breeding and two bright animals were spoiled in chemical analysis. Series V was the first generation of males from both bright parents and both dull parents, but the five brightest from the bright parents and the three dullest from the dull parents were reserved for breeding. The distribution of the learning scores for bright and dull combined was fairly normal with no indication of bi-modality. In both Groups IV and V the range of learning scores and probably the range of the magnitudes of chemical fractions were restricted. This may have reduced the coefficients of correlation presented in Tables 1 and 2 considerably.

**The age at chemical analysis for Series III, IV, and V rarely varied more than three days above or below the ages given.

Mazes

Three different mazes were used in this study. They will be referred to as mazes *A, B,* and *C.* Maze *A* was an easy maze which required, with a learning criteria of six successive perfect runs, 14 trials as a median for mature male rats. Maze *B* was a simple but very hard maze which required as a reasonably certain criterion of learning 80 per cent perfect runs out of 20 trials. With this criterion the median number of trials required of 61 mature male rats was 85. Both of these mazes were really only different alley patterns set up in the same apparatus which, except for several improvements was similar to the maze apparatus reported by Alm (1) In the use of this apparatus most of the retracing of alleys was prevented by quiet doors that were closed after the animal had moved out of sight. Tracing other animals and stops for traces of animals previously run were almost completely eliminated by elevating the sides of the alleys for ventilation and by moving the black oil cloth floor covering to a new position after each run The maze was enclosed by black drapes. The errors and time of running for each animal were observed in an over-hanging mirror For 61 male animals of similar ages to those of this experiment the coefficients of correlation between the sums of odd and even trials for error scores and time scores made in trials 7-80 were +.86 and +.85 respectively. The application of Spearman's "prophecy" formula for indicating the reliability of the total scores brought these correlations to +.92 and +.93 respectively. Maze *C* was an elevated maze with 12 T-shaped alleys with an alternation of single and double alternations of right and left turns The alleys were three inches wide and had metal sides one to four inches high The bars of the *T*'s were covered with black oil cloth strips that in the latter 20 trials of learning were changed after each run by the rotation of a roller Retracing was largely eliminated by dropping the hinged stems of the *T*'s behind the animal as it moved through the maze The coefficients of correlation between the sums of odd and even trials for trials 1 to 40 for 49 male animals 40 to 45 days of age at beginning learning was +.87 for error scores and +.96 for time scores[2] The distribution of practice per day was one trial for Maze *A*, five for *B*[3], and two for *C*.

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[2] The high correlation for time scores was due to unusually high time scores for several animals that were consistently timid, cautious, or slightly fearful. The correlation would otherwise be similar to the +.87 for error scores

[3] For animal series II the distribution of practice was three trials per day.

CHEMICAL ANALYSIS

For brain analysis in this study the micro method of Backlin (2), with slight modifications was used The fractions determined by this method were: I*a*, cholesterol; I*b*, fatty acids of unsaturated galactolipids; I*c*, fatty acids of unsaturated phospholipids, II*a*, fatty acids of saturated phospholipids; and II*b*, fatty acids of saturated galactolipids.

The fractions were finally isolated in test tubes from solutions in petroleum ether Backlin quantitatively oxidized these fractions, while in this experiment they were weighed.

Before beginning the chemical separation, considerable preparation of materials was necessary. The fresh brain tissue, freed of any large membranes or blood vessels, was passed through ordinary glass syringes of 2-5 ml. capacity. These syringes contained at their lower ends discs made of copper screen cut to fit snugly inside the hollow syringe cylinder The material was passed through alternate syringes until it was a homogeneous, pasty mass, 10 passages sufficing For a single determination, 60 to 100 mg. of this pasty brain material were spread upon two fat-free filter paper strips measuring about 17 x 28 mm The strips were quickly weighed to 0.1 mg. They were then placed in a vacuum desiccator and dried for an hour After drying, the strips were ready for the lipid separation procedure.

The following procedure in the use of Backlin's method for separating the various fractions was developed after considerable experience The steps, which are described in Table 2, are so arranged that the complete separation can be effected with a minimum loss of time For a single determination, four ordinary test tubes 3/4" x 6" were used, they were numbered 1, 2, 3, and 4 Four separatory funnels, holding about 50 ml and capable of being centrifuged, were used, and they were numbered 1, 2, 3, and 4

With few exceptions four samples of the brain of each animal were analyzed. Five lipid fractions were separated from each sample excepting the samples for animal Series V from which the saturated lipids were not separated. The weight of each lipid fraction was multiplied by 100 and divided by the weight of the brain sample. The average of these percentages constituted the chemical score The scores thus obtained for the several lipid fractions were then correlated with the different learning scores. Accidents during analysis

TABLE 2

PROCEDURE FOR SEPARATION BY *BACKLIN'S METHOD**

1^{2}_{3}	T 1	Extract dried strip in petroleum ether (Pet) 40 min.
${}^{1}2^{5}$	T 2	Further extract strip in boiling EtOH 60 min.
${}^{1}3^{4}$	T 1	Evaporate extract 1 nearly to dryness (5 min)
${}^{3}4^{6}$	T 1	To residue in T 1 and 5 ml. dry EtOH plus 0.2 *ml 15% NaOH and dry on salt water bath* (30 min.)
${}^{2}5^{9}$	T 2	To extract in T 2 add 0 2 ml 15% NaOH and dry on salt water bath (30 min)
${}^{4}6^{7}$	T 1	To residue in T 1 add 3 ml 5% NaOH, shake well, and pour into Sep 1 Extract the T 5 min with 10 ml. Pet.
${}^{6}7^{8}$	T 1 Sep 1	Transfer Pet from T 1 to Sep 1, shake 3 min, drain lower layer back into T 1 without breaking *salty surface, and centrifuge Sep 5 min.*
${}^{7}8^{12}_{10}$	T 1 T 3 Sep 1	From Sep 1 pour off Pet layer into T 3 and evaporate on water bath nearly to dryness (5 min.) To Sep add 2 ml 20% H_2SO_4 and then 3 ml H_2O. Shake Sep and draw off contents into T 1 Return Soln. to Sep and extract T 1 5 min with 10 ml. Pet
${}^{5}9^{11}$	T 2 Sep 2	To residue in T 2, add 3 ml. H_2O, shake well, pour into Sep 2 and rinse T first with 2 ml then with 1 ml of 20% 'H_2OSO_4 and drain into Sep 2 Extract T 2-5 min with 10 ml Pet
${}^{8}10^{14}$	T 3	To nearly dry T 3 add 5 ml 20% H^2SO_4 and heat 30 min in water bath
${}^{9}11^{13}$	T 2	Transfer Pet from T 2 to Sep 2, shake well 3 min., and alternately drain and centrifuge until ether layer is clear and water layer is returned to T 2.
${}^{8}12$	Sep 1 T 1 T 1c	To Sep 1 add Pet from T 1, shake 3 min., settle, draw off lower layer T 1 and pour off Pet layer into T Ic
${}^{11}13^{15}$	Sep 2 T IIa T 2	From Sep 2 pour off Pet layer into T IIa. Add 2 ml 20% H_2SO_4 and shake Draw off liquor into T 2 and heat 30 min on boiling water bath
${}^{10}14^{16}$	T 3 Sep 3	Cool T 3, transfer contents to Sep 3, treat with 6 5 ml 25% NaOH and cool Extract T 10 min with 10 ml. Pet.
13 15	T 2 Sep 2 T IIb	Cool T 2, transfer contents to Sep 2 Extract T 5 min with 10 ml. Pet, and transfer Pet to Sep 2 Shake 3 min., settle, draw off lower layer into T 2, and pour Pet into T IIb

TABLE 2 (*continued*)

	17	T 3	Transfer Pet from T 2 to Sep 3, shake 3 min., draw off lower layer into T 3, settle or centrifuge Pet layer, pour off into T 4, and evaporate nearly to dryness Wash Sep 3 with 2 ml 20% H_2SO_4, draw off into T 3, return to Sep and then extract T 3 5 min. with 10 ml Pet
14	18	T 2	
	16	Sep 3	
	—	T 4	
16	19	T 4	Treat residue in T 4 with 1 ml. 20% H_2SO_4 plus 3 ml. H_2O, warm 3-4 min in water bath, transfer to Sep 4 and extract the T 5 min with 10 ml. Pet
	17	Sep 4	
	—		
16		T 3	
	18	Sep 3	Transfer Pet from T 3 to Sep 3, shake 3 min. draw off lower layer, and pour Pet layer into T Ib
	—	T Ib	
17		T 4	
	19	Sep 4	Transfer Pet from T 4 to Sep 4, shake 3 min, draw off lower layer, and pour Pet layer into T Ia.
	—	T 1a	

*The column of underlined figures numbers the steps of the procedure The column immediately to the right of this column indicates the steps to which the material goes next The column at the extreme left indicates the steps from which the material comes The column at the extreme right indicates the marked glassware used

Pet=petroleum ether

T=test tube

EtOH=absolute ethyl alcohol

Sep=separatory funnel

made the number of chemical scores slightly less than the number of learning scores

RESULTS

The main finding from this investigation was a uniformly negative correlation between learning scores and the scores for unsaturated lipids as indicated in Tables 3 and 4 But since the larger the time and error scores the poorer the learning ability of the animal, these data show a positive relationship between learning ability and the scores for unsaturated lipids.

The correlations in Tables 3 and 4 indicate other possible tendencies and relationships that may be important. In the first place there is probably a more persistent relationship between learning scores and the scores for unsaturated phospholipids than between the same learning scores and the scores for unsaturated galactolipids This may be indicated by the low correlations between learning scores and the scores for unsaturated galactolipids for Series IV. The pro-

TABLE 3

Coefficients of Correlation Between Lipid Scores and Learning Scores

	Unsaturated phospholipids	Unsaturated galactolipids	Saturated lipids*	Cholesterol
Series II**				
Total distance	—235	—373	+262	+761
Total time	—119	—320	—062	+.757
Total trials	—.234	—427	+330	+.762
N=	15	14	14	15
Series III				
Errors				
Trials 7-C***	—.318	—.171	+354	+084
Trials 7-80	—314	—393	+176	+037
Time				
Trials 7-C	—.328	—483	—073	—029
Trials 7-80	—277	—551	—143	+012
Trials 2-80	—318	—584	—200	—.101
Time—Distance				
Trials 7-80	—217	—534	—430	—045
N=	19	19	19	19
Series IV				
Errors				
Trials 7-C	—053	—088	—.199	+.074
Trials 7-80	—113	—.096	—266	+078
Time				
Trials 7-C	—281	—.125	—.233	—012
Trials 7-80	—.381	—101	—.205	—.029
Trials 2-80	—326	—186	—096	—.086
Time—Distance				
Trials 7-80	—381	—065	—071	—088
N=	34	27	31	33

*The score for saturated lipids is the sum of the scores for saturated galactolipids and saturated phospholipids.

**Scores for Series II are sums of scores for learning in maze *A* and maze *B*

***Trials 7-C means from trial 7 to complete learning (16 perfect trials out of 20).

nounced drop in the correlations could be due to the greater quantitative of food stinting of series IV previous to and during learning[4] There is, however, another possible explanation for this fluctuation of the correlations between the scores for learning and for galactolipids

The scores for unsaturated galactolipids could not be so precisely determined They were only about one-eighth as large as the scores

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[4] This was done in feeding Series IV to make certain that food incentive would not at any time be lacking.

TABLE 4

COEFFICIENTS OF CORRELATION BETWEEN LIPID SCORES AND LEARNING SCORES, SERIES V

	Unsaturated phospholipids	Unsaturated galactolipids	Cholesterol
Maze *C* (Trials 1-40)			
Errors	— 141	— 212	— 178
Time	—.307	—.088	+ 255
Maze *B* (Trials 1-60)			
Errors	— 394	— 184	+ 127
Time	— 511	— 262	+ 352
Combined scores Mazes *C* and *B**			
Errors	—.278	— 240	+ 088
Time	— 428	— 192	+ 326
N=	40	37	39

*The numerical values of the scores for the two mazes were rendered roughly similar The error scores for the two mazes were similar in magnitude The time scores were made roughly similar before combining by weighting the scores for maze C and maze *B* ½ and 1 respectively Other weightings might have yielded combined scores showing higher or lower relationships with brain lipids.

for phospholipids. Their determination was therefore less precise.

The correlations in Table 3 indicate, in the second place, no certain relationship between learning scores and the sums of the scores for saturated lipids. The sums of these scores were used because Backlin's method was found very unsatisfactory for separating saturated lipids. But even the sums of the scores for saturated lipids did not correlate consistently with learning scores This may mean that there is little or no relationship between saturated lipids and learning ability. *However, the data on saturated lipids are inconclusive.*

In the third place there seems to be, as indicated in Table 3, a very possible negative relationship between learning ability and cholesterol This is evident from the correlations for animal Series II and V and is not materially contradicted by the correlations from animal series

II and IV On the other hand, since both the scores for unsaturated galactolipids and unsaturated phospholipids correlate fairly consistently with learning, it is surprising to find as may be observed in Table 7 that scores for cholesterol correlate positively with scores for unsaturated galactolipids but negatively with scores for unsaturated phospholipids. This possible inconsistency leaves the data not altogether clear as to what is the relationship between learning ability and cholesterol

While these latter findings are on the whole inconclusive or not altogether clear, the main finding is probably more significant than the low but persistent correlations taken alone really indicate.

Using the formula

$$P.E = \frac{.674\ (1-r^2)}{\sqrt{n}}$$

most of the coefficients of correlation in Tables 3 and 4 are not four times their probable errors and therefore are not statistically significant for each of the N's given for the several series of animals. Correlations of about ±.48 and over for Series III, of about ±.40 and over for Series IV, and of about ±.38 and over for Series V are at least four times their probable errors. In view of the inconsistency of the coefficients of correlation for saturated lipids and cholesterol their probable errors would be largely meaningless. For unsaturated phospholipids and unsaturated galactolipids, however, the general trend of the magnitude of the coefficients of correlation, and the fact that they are consistently negative should indicate a much higher reliability for the different coefficients than would be indicated by the probable errors. Moreover, in spite of somewhat different experimental conditions for the four series of animals, the general trend of the coefficients of correlation persisted For an *N* equal to the sum of the *N*'s for the four series of animals for either of the unsaturated lipids, coefficients of correlation of about ± 25 would be statistically significant. And it is believed that a general trend of the coefficients of correlation of — 25 or above would be fairly reliable statistically. At least, it seems unlikely that the coefficients of correlation for all of the animals taken as one series would be lower than the general trend of those obtained. There is no known spurious factor which could account for the positive relationship between learning ability and unsaturated lipids. However, the fact that the correlations between time scores for learning and the scores for unsaturated lipids tend to be higher than the correlations between error scores and scores for these lipids pointed toward the nutritional status of the animals as a very possible common factor. Of this factor the best available measure was body weight at the time of chemical analysis which means that age was held constant. In this connection it should be noted that the different animals in Series IV and V were fed in individual cages for several days before and during the whole time of maze learning exactly the same feed by weight and quality each day. With this feeding method the consistency of performance in the maze from day to day appeared better than for animals under group feeding Nevertheless, time scores correlate higher than error scores with the scores for unsaturated lipids. Tables 5 and 6 may indicate the significance of the higher correlations for time scores than for error scores. The considerable positive correlations between learning scores and body weight as shown in Table 5 for animal Series III would be especially disturbing except for the prevailingly negative correlation for Series IV and V.[5] Table 6 shows, moreover, an almost uniformly

TABLE 5

COEFFICIENTS OF CORRELATION BETWEEN BODY WEIGHT AND LEARNING SCORES

	Series II		*Series* III	*Series* IV		*Series* V
Total		Errors			Maze *C*	
Distance*	+ 146	Trials 7-C	+.240	+ 158	(Trials 1-40)	
Total		*Trials 7-80*	+ *156*	+.*142*	*Errors*	— 141
Time*	— 018	Time			Time	— 268
Trials*	+ 165	Trials 7-C	+.240	—.083	Maze *B*	
		Trials 7-80	+ 344	—.198	(Trials 1-60)	
		Trials 2-80	+ 529	—.267	Errors	— 108
		Time÷Distance			Time	— 319
		Trials 7-80	+ 409	— 246	Combined scores Mazes *C* and *B***	
					Errors	— 135
					Time	— 359
N=	15		19	35		40

*Scores in II are sums of scores for learning in maze *A* and maze *B*
**See footnote for Table 4

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[5] *The cause for this disagreement is not clear* The *group feeding of* Series III and individual feeding for Series IV and V may account for the difference

TABLE 6
COEFFICIENT OF CORRELATION BETWEEN SCORES FOR BRAIN LIPIDS AND BODY WEIGHT

Animal series	Unsaturated galactolipids	Unsaturated phospholipids	Saturated lipids*	Cholesterol
II	—288	—246	+.318	+.492
N	14	15	14	15
III	—.031	—119	—.086	—038
N	19	19	19	19
IV	—275	+135	—042	—084
N	27	34	33	31
V	+055	—033		—018
N	37	40		39

*See footnote ** for Table 3

low negative relationship between body weight (at analysis) and lipid scores. Now if the weight factor as evidenced by these correlations in Tables 5 and 6 were held constant or partialed out by the method of partial-correlation, the correlations between learning scores and lipid scores, as indicated in Tables 3 and 4 would not in any case be reduced more than 02 or .03. Such changes are negligible The differences in the nutritional status of the animals as indicated by differences in body weight were very probably unimportant factors in the correlations obtained.

In evaluating still further the main finding of this study, it should be observed that a high relationship between any one chemical component of brain tissue and learning ability would be very improbable. The multiple correlation for the two unsaturated lipids may have

TABLE 7
COEFFICIENTS OF CORRELATION BETWEEN DIFFERENT LIPID SCORES

	Series II	Series III	Series IV	Series V
Unsaturated phospholipids versus unsaturated galactolipids	+.293	+.075	+443	+222
N=	14	19	26	37
Unsaturated phospholipids versus cholesterol	+.031	—002	—.253	—.287
N=	15	19	30	39
Unsaturated galactolipids versus cholesterol	—357	+202	+086	+317
N=	14	19	27	37

some significance. The correlations between different lipid scores as presented in Table 7 show a fairly consistent positive relationship between the scores for the two unsaturated lipids The correlation of + 222 for animal Series V is probably most dependable because of the larger *N* and the better experimental controls that were obtained for that animal series. When these two lipid scores are taken as independent variables and learning ability for Maze *B* with number of trials constant is taken as the dependent variable the multiple correlation, $R_1(23)$, is + 532 for learning ability measured in terms of learning time, and +.402 for learning ability measured in terms of errors. The formula used was

$$R_{1(2\,3)} = \sqrt{1 - \frac{\sigma_{1}{}^{2}{}_{2\,3}}{\sigma_1{}^2}}$$

The results obtained indicate in this case how learning ability was affected by the combined influence of unsaturated galactolipids and unsaturated phospholipids

CONCLUSIONS

The data seem to warrant the following conclusions.

1. The acids of unsaturated galactolipids and unsaturated phospholipids are important brain factors in learning ability. The relationship between the acids of these lipids and learning ability is probably higher than the coefficients of correlation indicate even though body weight may have been in some cases a slightly spurious common factor.

2. For animal Series V the multiple correlation of the scores for unsaturated lipids taken as independent variables is + 532 for the dependent variable learning ability as measured by learning time, and +.402 for the dependent variable learning ability as measured by learning errors, with number of trials and age constant.

3. The fatty acids of unsaturated phospholipids may have a more persistent or uniform positive relationship to learning ability than the fatty acids of unsaturated galactolipids Further investigation is indicated.

4 Nothing conclusive can be inferred about the relationship between saturated lipids and learning ability. Backlin's method of separating saturated lipids is too unreliable to indicate any relationship consistently

5. A negative relationship between cholesterol and learning ability seems probable. However, this may depend upon which of the unsaturated lipid fractions relative to its average score, predominates. Cholesterol correlates negatively with the acids of unsaturated phospholipids, but positively with the acids of unsaturated galactolipids.

6. If brain lipids are organ specific, as Serejski claims, if they vary widely among different individuals as this study and a previous study indicate, and if they are necessary for the oxygen metabolism, or for some other activity, very essential to the behavioral functions of neurons, then the persistance of a positive relationship between unsaturated lipids and learning ability is especially significant. This relationship indicates that the acids of unsaturated lipids are probably definite neural factors in higher behavior functions the determination of which may be investigated from different modes of approach such as hereditary, nutritional, and physiological. But much careful experimentation with large numbers of animals, possibly of different species is necessary to determine the existing relationships conclusively Much experimentation of a cooperative nature between physiological chemistry and psychology seems worthwhile.

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BRAIN POTENTIALS FROM THE RAT*

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Types of Waves

With the same placement of electrodes we have been able to secure three types of waves (rhythmic electrical potentials) from the brain of an unanesthetized rat (Figure 1).[1] Because of their characteristic appearance we have named them as follows: (*a*) Random (Figure 1*A*). These are irregular waves associated with conditions of alertness of the animal. They present a variable frequency of around 40 per sec. and an intensity around 40 microvolts. Occasionally (see latter part of record) larger and slower waves (10 per sec.) can be made out in records of these random waves. (*b*) Bursts (Figure 1*B*). These are regular waves associated with conditions of relaxation of the animal. A warm room, satiation from feeding, and fatigue are conducive to their appearance. They present a relatively constant frequency of 7 per sec. and an intensity around 350 microvolts. (*c*) Extended (Figure 1*C*). These are regular waves associated with the bursts. They present a relatively constant frequency around 3 to 4 per sec. and an intensity around 175 microvolts. The random waves occur the most, and the extended, the least frequently.

Under ether anesthesia the rat gave rather consistently the type of regular, slow waves presented in Figure 2. They were around 2 to 3 per sec. in frequency and 100 microvolts in intensity.

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[1] The amplifier was one of those described in a previous communication (4) except that here we did not use a preamplifier. The electrodes were two silver wires, gauge 16 B. & S., slightly flattened at one end. The flattened ends rested on either the skull or the brain and were held firmly in place by means of dental cement. Our common electrode arrangement was to have one wire over the visual and the other over the motor area of the same hemisphere. We found no significant differences in brain potentials for different placements of the electrodes (one electrode attached to ear, the other over visual or motor area or one over visual and the other over motor area), or between those waves obtained with the electrodes resting directly on the brain and those with the electrodes resting on the skull.

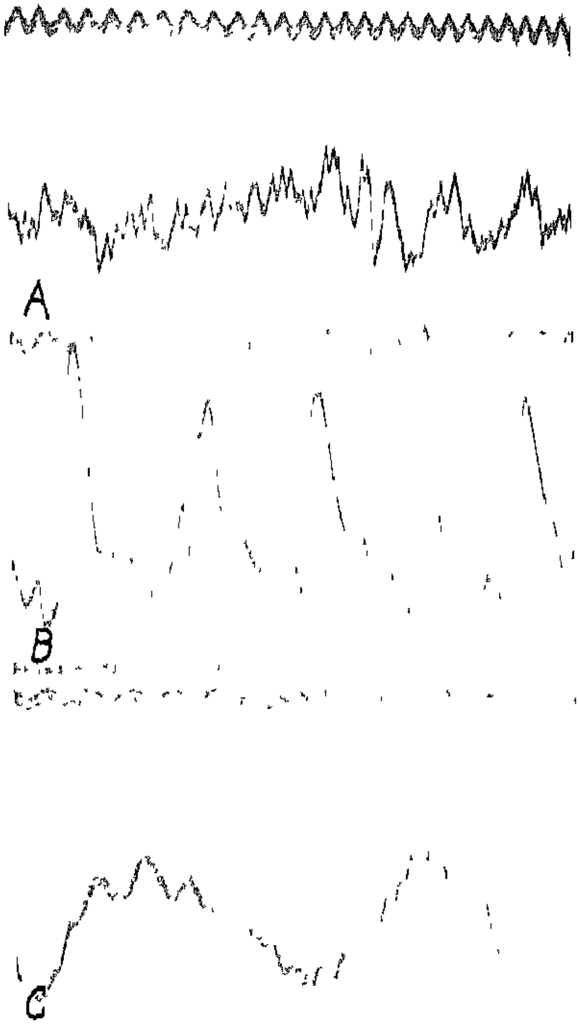

FIGURE 1

TYPES OF ELECTRICAL POTENTIALS FROM THE BRAIN OF AN UNANESTHETIZED RAT
A=random waves, B=bursts, C=extended waves. In these and subsequent records time=1/25 sec.

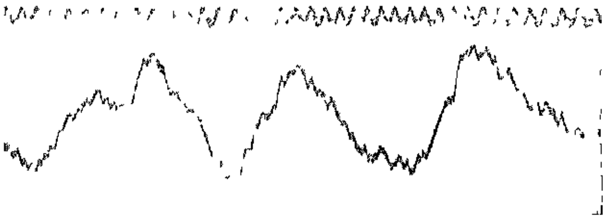

FIGURE 2
Brain Waves from a Rat Under Ether Anesthesia

Latencies

Neither movement nor any kind of stimulation we used had any appreciable effect on the random waves. Movement generally obliterated the bursts and extended waves. One rat, however, gave the bursts while he was scratching and cleaning himself as well as when he was quiet. A strong light (100 watt mazda bulb), a pure tone (3500 cyc., 60 db.), and a shout (70 db.) were relatively ineffectual in obliterating the bursts. Occasionally any of these stimuli would produce what appeared to be a true latency of around 0.20 sec. A latency was considered as the length of time elapsing between the appearance of the stimulus and the marked depression or obli-

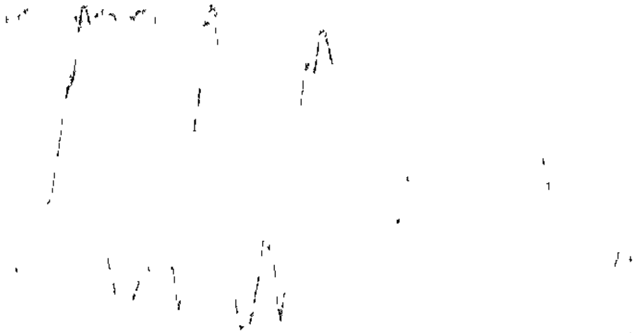

FIGURE 3
Record of Brain Wave Latency
The imitation "squeal" recorded at bottom. This latency read as 0.20 sec.

teration of the bursts The one stimulus that we found effective in depressing the waves in the bursts was an imitation of a rat's squeal In over 50 per cent of the trials this stimulus gave us objective records such as that presented in Figure 3 The following characteristics of records made them unreadable for latencies· the waves were reduced or disappeared very gradually, they were not affected, and they were absent at the instant of giving the imitation "squeal"

We secured 48 objective records, in all, of latency from 6 rats The mean latency was 0 20 sec and the range, 0 08 to 0 48 sec The standard deviation of the distribution was 0.0943 sec These latency values do not differ much from those reported on human subjects for light by Berger (1), Jasper (2), Loomis, Harvey and Hobart (3), and Travis, Knott and Griffith (4).

SUMMARY

We obtained three types of waves from an unanesthetized rat. (*a*) *Random* Irregular waves with a frequency of 40 per sec and an intensity of 40 microvolts, associated with conditions of alertness of the animal (*b*) *Bursts* Regular waves with a frequency of 7 per sec and an intensity of 350 microvolts, associated with conditions of relaxation of the animal (*c*) *Extended* Regular waves with a frequency of 3 to 4 per sec and an intensity of 175 microvolts, associated with the bursts

The random waves occurred the most, and the extended, the least frequently Under ether anesthesia the rat gave regular, slow waves with a frequency of 2 to 3 per sec and an intensity of 100 microvolts.

An imitation of a rat's "squeal" obliterated the bursts in 0 20 sec Other kinds of stimulation (light, oscillator tone, and human voice) were relatively ineffectual in affecting the bursts

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THE VOCATIONAL PREFERENCES OF SCHOOL CHILDREN*

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This study was made with school children in grades one to six, inclusive. Out of approximately 1640 record blanks 1561 were sufficiently legible, understandable and complete to justify the consideration of their results Of this group, 796 were girls and 765 were boys The age ranges were from five to sixteen, inclusive. These children lived in two urban communities in Tennessee, one of which is an industrial center, an urban community in Kentucky, a large consolidated rural school district in South Carolina, and two small communities in Mississippi and Oklahoma No school participated unless the administrative officer was sufficiently interested in the problem to assist actively in the accumulation of the data

In general the method employed should be called the questionnaire method. Each child who participated was presented the following question.

> When you get old enough to leave home and make a living for yourself, what kind of work do you want to do? For example, you might want to be a carpenter, a school teacher, get married and keep house, be a farmer, be a doctor, run a boarding house, work in a beauty parlor, or just any one of a whole lot of things Put down the ONE thing you would rather do than anything else when you get old enough to make your own living

With the exception of one of the small schools, all responses made by children in the first three grades came as a result of face-to-face questioning, or direct personal interview Above this level the children were permitted to answer the question by themselves at their own desks Just as in the first instance where the cooperating teachers were instructed not to lead the children in their choices, so in the latter they were told to render any assistance needed by way of

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explanation or making clear to each child that which was wanted. To be sure, questionnaire procedures are not impervious to criticism. At the same time, no more objective way of determining these choices was apparent. Again, it is recognized that some of the choices expressed were the whimsical impulses of the moment and that as a result the reliability of the questionnaire is reduced. It is not apparent, however, as to just how this difficulty could have been obviated by any other technique In other words, if the data were worthy of collecting at all it appeared that the procedures followed were as justifiable and trustworthy as any which might have been selected.

In addition to his vocational preference each child was requested to answer certain questions about the economic conditions of his home. It would have been well if some standardized rating scale could have been used. Since this was not practical at the time, this unstandardized procedure was followed. Subjective evaluations were worked out for the various responses The information sought, together with the score values assigned to the responses are presented in Table 1.

TABLE 1

Information	Score value
Either parent working regularly	5
Professional work	4
Semi-professional work	3
Skilled work	2
Semi-skilled work	1
Average of 1 room per person in home	2
Average .5 to 99 rooms per person in home	1
Radio in home	1
Electric refrigerator	1
Furnace or steam heat in home	1
Regular servant in home	1
Automobile owned by parents	1
Total number points possible	17

Each paper was scored in accordance with this scheme The economic score which was obtained certainly was not a perfect measure of the economic status of each home. It appeared, however, that it possessed unquestionable practical value in giving a rough idea of the general economic nature of the child's home background. In considering these questions it is well to remember that no child was requested to sign his name to his paper

TABLE 2

FREQUENCIES AND PERCENTAGE OF PREFERENCES FOR VARIOUS VOCATIONAL PURSUITS· GIRLS

Vocations Preferred	Numbers of children Ages 6	7	8	9	10	11	12	13	14	15	16	Percentage of children Ages 6	7	8	9	10	11	12	13	14	15	16
Teacher	33	42	49	40	41	39	24	12	2			36	42	43	38	37	32	30	28	14		
Doctor	1	2				2		1				1	2				1		2			
Farmer	1	1					1					1	1					1				
Clerk	4	4	3	3	2	3	1					4	4	3	3	2	2	1				
Mill or plant worker	14	11	8	4	5	1	1		1			16	11	7	4	5	1	1		7		
Preacher or Missionary					1	1										1	1					
Pilot							10											13				
Movie actor				4	4	6	1								4	4	5	1				
Nurse	7	17	12	12	12	15	13	6	5	1	1	8	17	11	11	11	11	16	14	36	25	33
Keep house—get married	21	14	24	20	18	23	3	5		1		23	14	21	19	16	17	4	12		25	
Beauty parlor worker	6	6	12	10	12	18	10	4	5			7	6	11	10	11	13	13	10	36		
Stenographer	2		1	3	4	9	7	2		1		2		1	3	4	7	9	5		25	
Office worker	1	3	1	2	4	2	4	1				1	3	1	2	4	1	5	2			
Railway worker		6											6									
Government worker		9											9									
Musician		1		2	4	10	3	4	1				1		2	4	7	4	10	7		
Miscellaneous		1	4	4	1	2							1	4	4	1	1	3				
Total cases	90	117	114	104	108	131	78	35	14	3	1											

TABLE 3

FREQUENCIES AND PERCENTAGE OF PREFERENCES FOR VARIOUS VOCATIONAL PURSUITS BOYS

Vocations Preferred	Numbers of children Ages 6	7	8	9	10	11	12	13	14	15	16	Percentage of children Ages 6	7	8	9	10	11	12	13	14	15	16
Teacher	1	3	2	1	3	3	1	2	2			1	4	2	1	3	3	1	6	10		
Lawyer	1	1	3	2	2	4	1					1	1	3	2	2	3	1				
Doctor	10	7	9	12	8	11	4	6	1		1	11	9	8	10	7	9	6	19	5		33
Farmer	18	19	17	23	22	16	16	1	4		1	20	25	16	19	18	14	24	3	20		33
Clerk	2	3	8	5	2	5	3		3			2	4	7	4	2	4	4		15		
Salesman	1	2	3	1	2	2	2	1				1	3	3	1	2	2	3	3			
Foreman				1	2	1									1	2	1					
Mill or plant worker	20	20	7	8	8	3	2	2				22	26	6	7	7	3	3	6			
Preacher or Missionary			2	2	4	1				1				2	2	3	1				13	
Pilot	3	5	8	12	14	13	12	2	3	1		3	6	7	10	12	11	18	6	15	13	
Sailor, soldier	1	1	1	1	5	9	2		1			1	1	1	1	4	8	3		5		
Movie actor				1	1	2	1	1							1	1	2	1	3			
Merchant	2	2	2	2		1		2				2	3	2	2		1		6			
Carpenter	3	7	4	5	11	6	3	1	1			3	9	4	4	9	5	4	3	5		
Keep house, get married	2	1	3	1	11	5	1	4				2	1	3	1	9	4	1	13			
Office worker	2		1	1			1					2		1	1			1				
Business excutive	1		2			5						1		2			4					
Railway worker	5		6	4	4	5	5	2	1	1		5		6	3	3	4	7	6	5	13	
Mechanic	2		1	2		1		2				2		1	2		1		6			
Government worker	10		5	8	7	6	1	2				11		5	7	6	5	1	6			
Electrician			4	2	1	1	1		1						3	2	1	1		5		
Musician				1	1				1						1	1				5		
Chauffeur	2	1	5	14	2	4	1	1		1		2	1	5	11	2	3	1	3		13	
Ball player		1	5	2	1	3							1	5	2	1	3					
Miscellaneous	5	4	14	10	7	10	10	3	2	4	1	5	5	13	8	6	9	14	9	10	50	33
Total cases	91	77	108	123	119	117	67	32	20	8	3											

In Tables 2 and 3 one finds a summary of the results for each age, from six to sixteen, for each sex Let us consider these tables separately at first, and accordingly give first attention to Table 2, which is for girls The most striking feature in this table is the frequency of pedagogical ambitions Thirty-five per cent of the girls, or, roughly, one out of every three, preferred teaching to any other occupation Furthermore, this preference did not result from some peculiar unimodality of a limited age range. To the contrary, within the age range of six to thirteen years, where the cases probably are sufficiently numerous to justify some general conclusions, teaching was the preferred profession of each age group.

Four different occupations dominate the entire field of girls' vocational interests or preferences Teaching has been mentioned. The other three are: getting married and keeping house, nursing, and work in a beauty parlor. Together they include 75 per cent of all the choices, or three out of every four girls are most interested in following one of these four occupational channels.

Getting married and keeping house is the only one of these four pursuits which shows any noticeable relationship with maturity Even here the decline of expressed preference in this connection with greater maturity is not consistent even within the age range of six to twelve years where the numbers are the greatest There is, however, some rather definite tendency for the older girls to express this preference less frequently. As to the cause of this, we can only speculate It may be, of course, that there is an increasing embarrassment connected with the open statement of this ambition as the girls draw closer to the period of eligibility It may be that increases in maturity are accompanied by a broadening of interests and hence a reduction of this elemental urge. The evidence in support of this hypothesis certainly is not conclusive. Thus, beginning at year six and continuing through year thirteen, the number of vocations mentioned by as many as ten per cent of the girls in each successive age group are. 3, 4, 4, 4, 4, 4, 4, and 5 The number mentioned by as many as five per cent of the girls are. 5, 6, 5, 4, 5, 7, 6, and 6 A still further interpretive approach is that the stating of the preference in question should be interpreted to mean that these girls actually did not want to enter upon an occupational career, but to the contrary, preferred to let their prospective husbands assume formal vocational duties. From this point of view these 129 expressed choices would be taken as a negative rather than a positive expression If this latter hypothesis is correct, then the diminution of expressed preferences for matrimony may be taken as a key to the actual awakening of specific vocational interests.

One other matter should be considered in connection with the point in question It may be argued, and with some justice, that *the children should not have been permitted* to list *matrimony*. According to this idea it would be assumed that the vast majority of the children had this as a fundamental desire and the inclusion of it in this list tended to confuse emotional, biological, and vocational ambitions The point was considered before the responses were solicited but no action with respect to it was taken due to the fact that the investigator was prone to subscribe to the previously mentioned hypothesis of this being an expression of a non-vocational interest, or at least a non-specific vocational interest.

In the main, the same general conclusions as regards girls' vocational preferences are reached whether these preferences are distributed according to the chronological or the educational maturity of the groups. Probably the most noticeable change in this respect relates to the point of getting married and keeping house. In Table 4 it will be seen that though there is a noticeable decline in the expression of this interest at around the fourth grade, there appears to be some tendency for the interest to be kindled in the later grades In general, though, there is a distinct lack of evidence of a progressive increase or diminution of interest in any particular *type* of occupational activity. We see this portrayed in Table 7 if attention is centered on the medians for each age group from year six to year thirteen, inclusive Again do we see it in Tables 5 and 6. In the first, one might see evidence of a slight tendency toward a greater professional and a smaller manual labor interest with added maturity It must be recognized, though, that the changes in percentage are small at all points which involve any appreciable number of children, and, even more important, these tendencies do not express themselves consistently throughout the age range. Table 6 presents an even greater hiatus, it being impossible to obtain any idea of the consistent development of vocational interests from one educational maturity level to another

When attention is turned to an analysis of the boys' responses, *we note quite early a wider range of vocational interest than was*

TABLE 4

PERCENTAGE OF VOCATIONAL PREFERENCES MADE BY EACH SEX IN EACH GRADE

Vocations	Sex	Grades 1	2	3	4	5	6
Teacher	B	3	2	3	5	2	1
	G	39	39	46	42	28	27
Lawyer	B	1	1	2	1	3	2
	G						
Doctor	B	8	7	13	11	7	7
	G	2					2
Farmer	B	25	16	17	2	22	13
	G	1	1				1
Clerk	B	5	6	3	2	6	4
	G	2	4	4	1	2	1
Salesman	B	1	3	3	1		2
	G						
Mill or plant worker	B	19	16	8	4	1	2
	G	15	12	1	2	3	1
Preacher or Missionary	B		1	2	2	2	
	G				1		1
Pilot	B	3	4	7	11	17	18
	G						1
Sailor or soldier	B	1		1	5	2	6
	G						
Movie actor	B				2	1	2
	G		1		5	5	1
Carpenter	B	4	6	6	5	4	5
	G						
Merchant	B	2	2	2	1	1	1
	G						
Nurse	B						
	G	8	14	8	11	17	17
Keep house — get married	B	3	1	5	6	4	2
	G	21	17	23	10	12	17
Beauty parlor worker	B	1			2		1
	G	7	8	11	16	13	10
Stenographer	B						
	G	1	1	1	3	5	10
Office worker	B	1	1		1		2
	G	2	1	1	1	5	3
Business executive	B	1		1	2	4	
	G						
Rail worker	B	6	6	6	1	4	7
	G						
Government employee	B	8	11	5	4	3	5
	G						
Mechanic	B	2	2	1	2		1
	G						
Ball player	B		4	1	2	2	
	G						
Electrician	B		1	3	1		2
	G				1		
Musician	B		1	1			1
	G	1	1	2	1	9	5
Chauffeur	B	3	4	1	4	2	5
	G						

TABLE 5

PERCENTAGE OF GIRLS OF EACH AGE WHO EXPRESSED OCCUPATIONAL PREFERENCES FALLING IN EXTREME VOCATIONAL GROUPS

Age	Groups 4 and 5	Groups 1 and 2
6	38	49
7	38	33
8	46	39
9	46	34
10	43	36
11	47	39
12	35	28
13	41	38

TABLE 6

PERCENTAGE OF GIRLS IN EACH GRADE WHO EXPRESSED OCCUPATIONAL PREFERENCES FALLING IN EXTREME VOCATIONAL GROUPS

Grade	*Groups 4 and 5*	*Groups 1 and 2*
1	41	45
2	57	38
3	47	34
4	48	36
5	41	38
6	43	33

seen among the girls' replies. Twenty-three different occupational groups with a frequency of five or more were listed by boys This is to be compared with 13 occupations mentioned with a frequency of five or more by girls The greater heterogeneity of boys' interests is seen in a still different way if one notes the number of miscellaneous answers. Quite arbitrarily it was decided to group all choices as miscellaneous if they did not appear as often as eight times in the combined boy and girl groups.[1] Only 12 of the girls' responses, or 015 of the entire group, were sufficiently random to be classified as miscellaneous. Despite 24 specific headings, as contrasted with 16 in the girls' table, 70, or .092, of the boys' responses had to be classified as miscellaneous. Furthermore, whereas three-fourths of the girls chose one of four vocational pursuits, the same percentage of boys chose some one of eleven pursuits. It appears quite evident that there was a much greater diversity of vocational interests among boys than among girls

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[1] The exception to this is *foreman*. It was presented specifically even though only four children indicated it This was done to enable the readers to make a direct comparison with the simple mill or plant worker preference

There are several rather prominent differences between the two groups with respect to their interest in certain specific occupations Thus, though 35 per cent of the girls preferred teaching, only two per cent of boys preferred this work. The percentage differences of 33 is almost 23 times its standard error and hence hardly to be considered the result of chance factors The other three most important vocations as designated by girls, did not appear among the boys' selections.[2] In turn, though 18 per cent of the boys expressed the desire to be farmers, only about 004 of the girls were comparably interested. About six per cent of the girls and nine per cent of the boys wanted to do mill or plant work. This difference is only about two and a fourth times its standard error and hence of doubtful significance. Also, the difference in desire to do clerical work in an office is too small to be significant

Though neither sex group expressed any tremendous interest in government work, e.g , post office worker, government agent, etc., the difference of some four per cent is approximately four and one half times its standard error and appears to indicate that one might be reasonably certain for boys to evince a greater interest in work of this type than is evinced by girls, assuming that the groups are selected in a manner comparable to those involved in this analysis. The boys also are significantly more interested in medicine as a profession. Also, the occupations of aviator, or pilot, carpenter, railway worker, and chauffeur, which are the remaining most frequently chosen professions mentioned by boys, do not appear at all on the girls' list.

As with girls, so with boys, there does not appear to be any particularly significant development or consistent modification of interests from year to year. Thus in Table 7 it will be noticed that there is no consistent increase or decrease of median occupational scores for the boys' group as a whole. Within the age limits of six to twelve, where the cases are most numerous, the greatest manifestation of interest in the higher vocational groups appears to be at year eight

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[2] The keeping house-getting married classification found in the boys' column is really a misnomer It should be taken to indicate a desire to run a rooming house, boarding house or some form of hostelry Since several of the boys expressed this as a desire to "get married and keep boarders", or something similar, the caption was retained

TABLE 7

VOCATIONAL PREFERENCES IN TERMS OF TAUSIG'S FIVE-GROUP SCALE* FOR ALL CHILDREN AND FOR THOSE OF HIGH AND LOW ECONOMIC STATUS

Age	No cases—each extreme group				Median scores					
	Boys		Girls		Boys			Girls		
	High	Low	High	Low	Whole	High	Low	Whole	High	Low
6	15	5	11	14	2.11	2.20	2.00	3.33	2.25	4.86
7	24	7	21	12	1.92	2.50	2.13	3.09	3.29	4.50
8	20	12	22	16	2.55	2.75	1.70	3.22	5.33	4.70
9	23	12	29	25	2.45	2.67	2.33	3.30	2.82	4.61
10	16	9	24	24	2.05	2.39	2.20	3.16	3.83	2.50
11	31	13	31	16	1.52	3.06	2.19	3.27	2.94	3.00
12	12	12	17	16	2.38	3.00	2.50	3.09	2.69	4.50
13	2	14	7	9	2.27		2.22	3.07	2.75	3.33

*A score of 5 designates the professional class, one of 1 the unskilled labor class. Intervening scores are to be taken accordingly. In computing medians the scores of 5, 4, 3, 2, and 1 were taken as the mid-points of the class-intervals which included them. Miscellaneous choices were excluded in all computations.

TABLE 8

PERCENTAGE OF BOYS OF EACH AGE WHO EXPRESSED OCCUPATIONAL PREFERENCES FALLING IN EXTREME VOCATIONAL GROUPS

Age	Groups 4 and 5	Groups 1 and 2
6	17	63
7	17	73
8	24	48
9	16	52
10	16	62
11	25	50
12	14	55
13	25	62

The trimodality pictured in Table 8, however, makes one feel that there is no true predominance of any one age group over the other. The irregular fluctuations tend to induce one to account for the condition in question in terms of an abnormal population sampling. The most significant change in boys' attitudes toward a particular occupation came with respect to that of mill or plant worker. In this instance there does appear to be a definite diminution of interest with increasing maturity. For groups of comparable selection it would seem that the chances are considerably less than one in one hundred that one would not find a decrease in this interest between seven- and eight-year-old boys.

Taken as a group the boys were less professionally inclined than were the girls This is seen in Table 7 and also in Tables 5 and 6 and Tables 8 and 9. Within the most populous age range, six to twelve, a smaller percentage of boys expressed a preference for professional and semi-professional pursuits than did girls, at every age Also, boys at every one of these ages evinced a greater interest than girls in unskilled and semi-unskilled vocational activities. In

TABLE 9

PERCENTAGE OF BOYS IN EACH GRADE WHO EXPRESSED OCCUPATIONAL PREFERENCES FALLING IN EXTREME VOCATIONAL GROUPS

Grade	Groups 4 and 5	Groups 1 and 2
1	13	62
2	15	55
3	25	41
4	29	34
5	20	40
6	15	38

Table 7 it will be noticed that at every age the median occupational score of girls is higher than that of boys This, of course, points still further to the main fact previously developed in this paragraph. This is seen in a still different way when all ages of each sex group are put together and their occupational scores tabulated. The boys' median of 2.32 is 1.87 lower than the girls' median of 3.19. This median difference is almost twelve times its probable error. Certainly it must be taken to point to a fundamental difference in the type of occupational preferences of the two sexes. The lowest quartile point of boys, 1.74, is only .39 lower than that of girls, 2 13, and though indicative of a definite difference in the lower halves of the distributions, does not point to as much difference as was seen at the medians. In other terms, boys and girls interested in what might be called the lower-order occupations are in closer agreement as to how low these occupations should stand than are average boys and girls When the upper halves of each sex group are studied, though, very decided differences are seen. The highest quartile point of girls, 4.89, is 1 65 higher than the corresponding point, 3.24, in the boys' distribution This difference, incidentally is over 25 times its probable error, and seems to indicate a quite unequivocal tendency for the girls more than the boys, who are not content with what might be called the lower order occupations, to have set their vocational ambitions far from the point of mediocrity. Without doubt, of course, girls' interest in teaching is mainly responsible for this excessive difference. If a girl is not content with skilled labor activities, teaching is almost the only available vocational avenue.

One other factor of some seeming significance remains to be analyzed That is the relationship, if any, which exists between the economic status of the children and their vocational interests. All papers were scored on the previously mentioned economic rating scale, and the scores thus obtained were thrown into one general distribution. Due either to an abnormality in the scale or to the nature of the groups tested there was a very distinct bimodality in the group It was intended that the highest and lowest 20 per cents of children, as determined by this distribution, would be selected for further study The distribution was of such nature, though, that, if all those scoring one more point had been included there would have been entirely too little selectivity in the group Those in the upper group arranged themselves more satisfactorily from the point of view of the investigator. About 21 per cent of the highest cases are included; this compares with about 14 per cent of the lowest cases. In Table 7 one finds a general summary of the results of this phase of the investigation.

At every age of those presented in the table, boys from the more favored economic strata are somewhat more professionally interested than boys from the less favored economic strata. For fear we begin to generalize on this too soon, however, we should note that in four of the eight age groups shown boys from the low economic group had a higher average occupational score than the average boys of the ages in question. In still other terms, one does not find an internal consistency for the various economic levels within all the age ranges. This certainly adumbrates the meaning of the data to some extent Nevertheless, with a total group median for the high boys of 2 72 and one of 2 18 for the low boys, we find a median difference which is 4.2 times its probable error and hence sufficiently significant statistically so as not to be passed off as a mere accident

If from these facts we conclude that a favorable or unfavorable economic background *per se* is the major conditioning factor in determining the nature of a child's vocational preferences, we find ourselves in difficulty when attention is turned to the girls. In contradistinction to boys, the high girls have a higher occupational score than the low girls in only two of the eight age groups shown in Table 7 Also, in only five of these years is there a consistent increase or decrease in medians from the high group, through the total, to the low group. Interestingly, four of these, years six, nine, twelve and thirteen, ascend from low to high, and one, year ten, descends from high to low There is another point of particular significance, however. *Whereas the data for the boys appeared to indicate that* economic plenty tended to be accompanied by a more professional type of vocational preference than economic insufficiency, with girls the opposite conclusion seems to be forced upon us. During the ages six, seven, eight, nine, and twelve, in particular, do we find the girls from the lowest economic strata evincing a far greater professional interest than those from the most favored economic backgrounds. Furthermore, *a median vocational score of 4 62 for the total group* of low girls when compared with a median of 2 99 for the high girls (critical ratio of the difference equal to about 7 3) almost makes it mandatory that we conclude that economic insufficiency is a most significant factor associated with the professionalization of girls' vocational ambitions. Since the opposite type of conclusion appeared when attention was concentrated on the boys' distributions it must be manifest that while economic environment may be somewhat related to the vocational interests of children it is practically impossible to show that this is a causal relationship, for groups, at least

There are certain other factors of some interest in these data We found a reliable difference in the median occupational scores of the total groups of boys and girls When attention is centered only upon the high boys and high girls, the median difference is only about 1 5 times its probable error, and hence to be interpreted as probably being too slight to be significant. When we turn to the low boys and girls, however, the difference is quite unequivocal, being 13 times its probable error It appears that our previous discussions as to the median difference between the two entire sex groups resulted mainly from the desires of the economically least favored girls to evolve into the most highly ranked occupations. The question is quite pertinent, though, as to why the boys of comparable economic restrictions did not react comparably Did these boys accept reality more than the girls? Had they thought more about their vocational careers and consequently come to recognize their own potentialities more? Were they more fatalistic than girls, or more prone to see the futility of these higher ambitions? If any of these questions is answered in the affirmative, we still have the question as to why such a condition exists Certainly this sex difference is not biological in origin Obviously it must reflect differences in training. When this is said we are still left with the source of this training. Did it come in the home? In the school? In companionship with other children? If any of these things is true the question seems pertinent as to why maturity is a factor of so little consequence.

It appears obvious from this study of the vocational interests of children that certain commonly accepted hypotheses are of doubtful validity In the first place, with the exception of an exceedingly small number of specific vocational pursuits children's occupational interests do not seem to grow or develop or systematically change within the years here considered. Again, economic security or insecurity in and of itself does not appear to be related causally to the occupational preferences of children Again educational maturity has a most equivocal relationship with professional interests. Certainly there does not appear to be any reason for assuming that all increases in educational achievement, or scholastic maturity, are accompanied by concomitant changes in a child's vocational outlook. If this is true, it cannot be said that education *per se* is the major determinant of children's occupational selections Again, though sex does play a significant rôle in quite a few instances, we see other instances where it does not and we must recognize that its relationship to vocational preferences is secondary rather than primary, it is related but not causally The sex differences which appear, without doubt, are the artifacts of a system of social training that in many cases approximates coercion Still further, whenever the origin of vocational, or for that matter most other interests, is explained in terms of some one element, force or changing factor, such an explanation likely will do an injustice to the facts of child development Many of our atomistic concepts of development must give way to the realization that a highly complicated organism is reacting to a multiplicity of interrelated forces or completely integrated environmental influences

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COLOR AND PICTURE CHOICES OF YOUNG CHILDREN*

From the Lincoln School, Teachers College, Columbia University

GERTRUDE H HILDRETH

The preferences expressed by young children for colors and pictures under experimental conditions are important for two reasons, first, the data for preferences expressed by children before their tastes have been formed by training indicate developmental trends in the aesthetic field, and, secondly, the information is of practical significance to parents and educators in selecting colors and pictures suitable for children To obtain new evidence concerning children's color and picture preferences the following experiment was conducted.

THE SUBJECTS AND THE TESTS[1]

A battery of color and picture choice tests constructed for experimental purposes was given by the writer to 138 children, 78 boys and 60 girls between the ages of three and six These children were attending a nursery school, and kindergarten and first-grade classes in a private experimental school. On the whole the subjects were above the median in intelligence as measured by standard tests appropriate to the various age levels. The median intelligence quotient for the group was 120 8 for children under five years and 120 for children above five years.

For color naming and color choice tests, standard colored papers were selected in ten colors· black, gray, green, red, purple, yellow, pink, orange, blue, brown, and specimens of each of the ten colors 1 3/4 x 3 1/4 inches in size were mounted on a large cardboard in the following colors

Pink	Gray	Green	Red	Purple
Yellow	Black	Orange	Blue	Brown

Ideally, color choice testing should be done with pure saturated

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[1] The writer is indebted to Professors Lois H. Meek and A T Jersild of Teachers College, Columbia University, for the opportunity to use as subjects children at the Child Development Institute

colors like those of the spectrum, such as may be obtained through the use of colored lights. For practical purposes pigment colored materials are satisfactory, though the difficulty of obtaining standard shades in any particular color is appreciated by all who attempt to select standard colors. Since for practical purposes we wished through color choice experiments to determine which colors children prefer in their surroundings, their play materials, clothing, and the like, the use of colored paper or cloth was admissable

Each child was shown the board containing the colors and asked to name them starting with the color in the upper left-hand corner and proceeding across the row. The color naming test not only indicated the child's familiarity with these ten colors, but also required the child to fixate each color separately before expressing a color preference. Following the test of color naming, the child was asked to tell which of the colors he liked the best. If a child named more than one, he was asked to tell which of those named he preferred. Verbatim responses for color naming and color preferences were recorded on appropriate blanks. Although the children were not asked why they preferred certain colors, they occasionally volunteered the reasons for selection.

In summarizing the data, children tested were divided into two groups In one group were placed all those who were from three to four years of age, in the other, those who were five and six years of age The first group had a median age of four years, three months; the second group a median age of six years, one month The color naming results for both age groups were as indicated in Tables 1 and 2.

Choices for the most part were made quickly Only a few children in each age group hesitated while making choices, or were unable to express a final preference for one color Dislikes were often as marked as preferences, and spontaneously given by the children One six-year-old volunteered the remark, "I hate black, don't you?" The most frequent reason for choosing a color was, "That's the prettiest." Another reason given was, "That's the color of my dress" Several children seemed to prefer black possibly because they had recently been using black paint in painting their boats and engines

For a number of reasons, different experiments yield contradictory results in color preferences Subjects used vary in age and maturity,

TABLE 1

COLOR NAMING

Under 5			Over 5		
No of colors correctly named	Frequency	%	No of colors correctly named	Frequency	%
10	17	30.3	10	61	75.2
9	17	30.3	9	14	17.3
8	11	19.6	8	2	2.5
7	3	5.35	7	4	4.9
6	1	1.8			
5	1	1.8			
4	2	3.6			
3	2	3.6			
2	0	0.0			
1	1	1.8			
0	1	1.8			
	Total 56*			Total 81	

*One child who had the remaining tests in the series missed the color naming test.

TABLE 2

COLOR CHOICE RESULTS

Age group Under 5		Age group Over 5		Both age groups combined	
Color	Frequency	Color	Frequency	Color	Frequency
Orange	14	Orange	28	Orange	42
Pink	12	Pink	12	Pink	24
Yellow	9	Red	11	Red	15
Blue	6	Purple	9	Purple	14
Purple	5	Green	8	Blue	12
Red	4	Blue	6	Yellow	11
Green	2	Black	4	Green	10
Black	1	Yellow	2	Black	5
Brown	1	Brown	1	Brown	2
Gray	0	Gray	0	Gray	0
No choice	2			No choice	2

the colors used are not always of equivalent or standard shades, the factor of suggestibility may enter into the test, or the way in which the test questions are framed. Results vary with the materials, cloth, paper, yarn, and lights, used in testing. The degree of experience with color is also responsible for varied results. Normally young subjects are unstable in expressing color and other preferences Retests frequently indicate contrary results. Actually, young children have difficulty in making a final choice and may make a selection more or less at random. The small number of cases involved in most experimental data increases the error due to sampling.

PICTURE PREFERENCES

Most nurseries and classrooms are ordinarily equipped with picture materials selected by adults on the basis of their own judgment as to what children like. Too seldom has any serious attempt been made to discover what children's natural picture preferences are Too frequently the publishers or decorators set the standards without reference to the genuine preferences of children. The results from an experimental study should have practical value in the construction of books and instructional materials for children, as well as for general decorative purposes.

The present study represents an attempt to determine what picture subjects young children prefer. Two types of picture preference tests were given In the first place, the child was asked to select on the basis of preferred subject, and in the second place, the child was asked to select on the basis of color versus black-and-white or monotone reproduction. The first of these tests consisted of 16 pictures representing a wide range of subjects, shown four at a time in the same order for each child. The four pictures were placed in a row before the child, who was asked to tell which one he liked best. Each time a choice was made, the chosen picture was extracted and kept for a final test. After the child had indicated his preference in each of the four groups of four pictures, he was shown the four pictures for which he had expressed preference and was asked to select the one he liked best of all

The 16 pictures used in the test were selected by the examiner from a variety of materials, some of which children were known to react to favorably, neutrally or even negatively The final 16 were chosen in conference with teachers as being most representative of a variety of subjects, and most uniform in color effects. It was necessary to use colored pictures in the picture choice tests in order to hold the children's interest and focus attention, for previous observation had indicated the distaste of young children for monotone pictures as compared with those brightly colored Color choice tests had also indicated this fact.

It was impossible because of limited time for individual testing and the short attention span of the children to lengthen the picture choice test so as to include a still wider variety of subjects It is possible that children might have shown predominant preferences for subjects not included in the present series. Color seems to have had less influence on the children's preferences than the subject of each picture, for among the best liked pictures were several less striking in color than those receiving fewer votes. All the pictures in the test inclined more toward realistic than the impressionistic style in painting, though there was some range in style and quality in the series.

TABLE 3

Picture	Artist	Subject
1 Young Mother Sewing	Cassatt	Child leaning over mother's lap
2. Wild Flowers of Ohio	Crow	Varicolored late summer flowers
3 Red Jacket	F. V Smith	A large, full rigged sailing ship
4. Behind the Plow	Kemp-Welch	Man plowing with team of two horses Birds fluttering over the newly plowed earth.
5 A Maine Coast Fisherman	Margulies	A man in oilskin coat against a seascape background
6 Fifth Avenue Bus	From Raphael Tuck Picture Book	A green, double-decked bus full of passengers going down a crowded street
7. St. Ann's Gate	Eddy	A peaceful, cheerfully colored street scene
8 A Distinguished Member of the Humane Society	Landseer	Large Newfoundland dog
9 Hiawatha's Wedding Journey	Ferris	Indian couple walking through forest
10 Don Carlos	Velasquez	Young prince galloping on a pony
11. Fruit	M Gray	A tray of brightly colored fruit
12 Little Brother	M O Kobbé	A girl aged about twelve, holding her baby brother
13. *Die Kleinen Tierfreunde*	*S Glucklich*	Girl seated on a bench holding a white bunny fed by a boy seated on the ground
14 Grand Canyon from Grand (Canyon Lodge)	H R. Henry J Freeman	A view of the Grand Canyon in pleasing colors
15. Day Dreams	From Raphael	Adolescent girl gazing pensively at a bright bowl of flowers.
16. Automobile at Filling Station	Tuck Picture Book	A red automobile with passengers stopping at a filling station

The 16 pictures chosen were trimmed to approximately the same size (10" x 7") and mounted on uniform sheets of gray cardboard. The pictures chosen are indicated in Table 3.

Famous masterpieces familiar to children were avoided in general, with the exception of the Landseer Occasionally children recalled having previously seen one of the pictures, but the general vote indicates that previous experience had little effect on choice, for the picture receiving the most votes in both age groups was a totally unfamiliar German print. The final vote (Tables 4 and 5) showed also that choice was quite independent of the position of the pictures in the row.

As in making color choices, most of the children expressed preferences with little reflection, though often the younger children were less prompt and certain in choosing than were older children. Younger children showed more tendency to choose by position than older children. The tests were given in the Spring of the year, a fact that may have been responsible for some of the preferences expressed.

After the final choice was made, each child was asked to tell why he had chosen the preferred picture Comments such as the following, particularly from older children, were common.

Rabbitt:
"I have one at home," "It's spring," "He looks nice," "I like rabbits and wish I had one," "Because it's picking flowers."

Bus:
"I've been on one a lot"

Flowers
"All those colors in them" "Pretty flowers."

The results indicate the overwhelming preference of young children for pictures portraying action and those including animals. If any sex difference was apparent, it was found in the greater interest of girls than boys in the mother-child type of picture.

Picture Choice. Color versus Monotone

In this test the child was shown the picture entitled "Roman Girl at a Fountain" by Bonnat, one in color, one in black and white, one a line drawing of the same subject, and one a black and white silhouette The pictures were all mounted on uniform sized boards and arranged in the following order: monotone, outline, color, sil-

TABLE 4

PICTURE CHOICE

Age group Under 5		Age group Over 5	
Picture	Frequency	Picture	Frequency
3	22	3	38
4	14	4	21
2	13	2	19
1	8	1	3
6	23	8	38
8	21	6	25
7	10	7	12
5	2	5	7
12	28	10	34
10	14	9	21
9	8	12	19
11	8	11	4
13	29	13	34
16	17	14	34
14	7	16	10
15	3	15	2
No choice	1	No choice or two choices	3

TABLE 5

PICTURE CHOICE

		Final vote			
Age group Under 5		Age group Over 5		Both age groups combined	
Picture	Frequency	Picture	Frequency	Picture	Frequency
13	12	13	18	13	30
8	9	14	13	8	16
6	6	3	11	14	13
12	6	10	9	12	13
2	4	8	7	10	13
4	4	12	7	3	12
10	4	9	4	6	9
16	4	2	3	2	7
7	3	4	3	4	7
5	2	6	3	16	5
1	1	7	1	9	5
3	1	15	1	7	4
9	1	16	1	5	2
11, 14, 15	0	1, 5, 11	0	15	1
				1	1
				11	0

houette, the monotone appearing on the child's left. Decisions in most cases were very quickly made. Results are indicated in Table 6.

TABLE 6

PICTURE CHOICE—STYLE

Age group Under 5 Style of picture	Frequency	%	Age group Over 5 Style of picture	Frequency	%	Total group Style of picture	Frequency	%
3	31	54.4	3	61	75	3	92	66.6
4	10	17.5	4	8	9.8	4	18	13.
1	8	14	2	7	8.6	1	13	9.4
2	8	14.	1	5	6.1	2	15	10.9

CONCLUSIONS

Two groups of young children between the ages of three and six, above the average of the general population in mental maturity, were asked to name ten colors, to name the preferred color, to express preferences for picture subjects among a series of 16 pictures, and to express a preference for reproductions of a single picture in four styles.

Results of these experimental tests indicated that nearly a third of the group below five years of age could name ten colors, and the same number, nine colors. In the group over five years of age, 75 per cent named ten colors and 17 per cent named nine colors correctly.

Orange was the favorite of both age groups, with pink second and red third.

In the picture choice tests, the picture of a boy and girl feeding a white rabbit was the final preference shown in the votes of both age groups, the picture by Landseer of a large dog second. A view of the Grand Canyon and a picture of a girl with her baby brother tied for third place.

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THE EFFECT OF THE PRESENCE OF A SECOND INDIVIDUAL ON THE CONDITIONED SALIVARY RESPONSE IN DOGS OF DIFFERENT CONSTITUTIONAL TYPES*

From Cornell University

W. T James

It is generally assumed that a given individual will perform certain mental processes and associations in a characteristic manner It is further recognized that these mental reactions are subject to variation depending upon whether the individual is alone during the reaction or is in the presence of another person. It is still further known that the presence of a companion, and especially a stranger, is far more disturbing for certain individuals than for others Partly on this account some persons are companionable or social while others are more solitary in their habits. Both psychologists and biologists disagree as to the causes for this difference in social behavior. One group relates the social reaction entirely to the past experience of the individual while a second group emphasizes the constitutional and inherited factors Evidence is found in support of both influences. Experiments of various types have been tried for interpreting the social behavior of the human. The problem is difficult because of the inability to analyze both the genetic factors and the environmental experiences For this reason the basic processes involved in social behavior should also be studied by recourse to animal experimentation. It is essential for this purpose to use animals which show variations in constitution and type reactions Dogs exhibit certain social behaviors closely similar to those seen in the human.

At the Cornell Anatomy Farm a large number of dogs are being studied and arranged in behavior groups on the basis of salivary and motor reflexes. Since it is necessary to keep many of these animals together, each dog is forced to associate with and react to others It is found that in all groups certain animals dominate or suppress others In some cases one dog will dominate only a single animal

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of a group while the other members will not be disturbed by his behavior. An aggressive dog may be dominated by another dog and still maintain his supremacy over all of the other dogs of the group. There are other animals that are dominated by every member of the group. Such a dog would be called timid, shy, or extremely inhibitible. We have found that some individuals are always aggressive in any group Aggressiveness and dominance are expressed simply by asserting mastership of the situation, and this position is maintained very often at the expense of a fight. One phase of aggressiveness is expressed by taking food away from the other animals. Aggressiveness is expressed also by taking the choice place on which to lie in the kennel, or by driving another animal away in order to receive the attention of the keeper for himself. The more timid and dominated animals crouch down and withdraw as soon as the aggressive dog approaches If they do not withdraw immediately, the aggressive dog growls. As a rule the growl or snarl is all that is necessary to intimidate the shy dogs If there is opposition, the aggressive animal attacks. From casual observation it would seem that the more combative animal becomes the aggressor, while in many cases even the stronger and larger dog, though less combative, withdraws. The timid dog may actually be well able to take care of himself in a fight if he were willing to contest the situation.

In this series of experiments an attempt is made to analyze these reactions and determine their relation to the physical constitution of the dog. The dogs were studied first as individuals and then in the company of associates to which they had already made adjustment.

We may consider first the behavior in a litter of five animals, three females and two males. These dogs have been together from the time of birth The animals are now two years old and have been studied experimentally for one year. The parents were derived from a hybrid between a bassethound and a German shepherd bred back on the bassethound. The parents were therefore three-fourths basset and one-quarter shepherd. The litter of five, from these parents, is fairly homogeneous with physical characteristics predominately bassethound. Before describing the behavior of these animals under experiment, their behavior toward one another in the open kennel will be considered.

The dogs are referred to by their record numbers Female 1301 is extremely shy and timid, being imposed upon and dominated by all the others. She shrinks away from the food pan when any one of the others approaches She retreats with a crouched body, and, when growled at, lies down on her back and becomes completely passive She does not attempt to eat along with any of the others, but runs from pan to pan as they leave, taking food that remains Her timidity is expressed also toward people When a kennel man, the experimenter, or a strange person approaches she moves into the background while the other four litter mates come forward for attention An excellent example of this behavior is shown in the photograph (Figure 1) Four dogs are seen in the foreground, but the extremely shy animal remains in the background, avoiding the photographer She is the least aggressive one of the group and is completely dominated by the four brothers and sisters Among the four dominating this shy animal, a definite order of dominance and suppression has been formed One of the males, 1297, dominates the other male, 1298 This dominance is expressed by chasing the other away from the food pan, growling, attacking, and by running 1298 out of the kennel house at various times The dominated dog, 1298, is always forced to move back when the experimenter is

FIGURE 1

THE TIMID DOG, NUMBER 1301, REMAINS IN THE BACKGROUND WHILE THE FOUR OTHER ANIMALS COME FORWARD THE DOMINANT MALE IS TAKING FOOD FROM THE PAN offering food by hand, while the dominant dog, 1297, comes forward. When one of the females is in oestrus there is constant antagonism between the males with animal 1297 driving animal 1298 away from the female. Often during the night it is necessary to go into the kennel and quiet the two males; they growl and constantly antagonize one another. This snarling is always started by dog 1297 and is continued even after 1298 has retreated into the corner. A somewhat similar relation, though not so pronounced, exists between the two females. Female 1300 is aggressive and definitely dominates 1304, as expressed by grabbing away food, pushing, and attacking. Dog 1300 invariably gets attention at the expense of 1304. It has been observed on several occasions that dog 1300 would growl and bark at 1304 with no apparent reason and would continue to do so until scolded by the experimenter. The dominant female 1300, although never taking the direct aggressive against the two males, will not allow them to take food from her or move her out of a choice place in the kennel. She is not aggressive toward them, but neither is she dominated by them. Finally, among the five dogs, one female is dominated by all the others; among these four, one male dominates the other male, one female dominates the other female, and although this dominant female does not take the aggressive toward the males, she is not dominated by them.

In the experiment the animals were first studied as individuals with the conditioned salivary reflex in order to compare them with more than 40 other pure breed and hybrid animals that have already been trained.

The laboratory is a quiet, isolated room in which the dog remains during the presentation of food and various conditioning stimuli. During the early training a harness was used to confine the animal, but it was discarded as soon as the animal became adjusted to the situation and would take food without hesitation. The salivary response was recorded by means of a manometer and a tube held tightly over the parotid fistula by a suction cup arrangement. The movements of the experimenter were not visible to the dog during the training. A metronome sounding at the rate of 120 per minute was used as a signal for food. On certain days kymograph records were made of the salivary response, the breathing changes, and the head and body movements. In order to facilitate comparison among these animals, the results of the study are presented in Table 1.

TABLE 1

COMPARATIVE BEHAVIOR OF FIVE LITTER MATES ON THE BASIS OF CONDITIONED SALIVARY REFLEX

Number of dog	No. of days in laboratory before dog takes food	No. of M 120 before cond. salivary response	Value of salivation in 1/100cc for 30 sec Average of 25 days	No of negatives M 18 given before differentiation	Percentage of responses to M 120 throughout training
1301	7	no cond. response		..	
1300	5	14	11 4	12	92
1298	7	20	16	25	92
1304	6	12	16	11	100
1297	6	8	22	20	100

The table shows that female 1301, which was dominated by all the others, is very different from the others and inferior to them under laboratory conditions. Although this animal took food at times, she did so only when extremely hungry. She never entered the laboratory without crouching and being afraid, she would hesitate, lean in the harness, and stand as near the door as possible, suggesting an eagerness to get out. This disturbance, caused possibly by the laboratory, the experimenter, the harness, etc., placed the animal in so complete a state of *inhibition* that a conditioned response, and often even the unconditioned response, was impossible to obtain.

The other four dogs developed excellent responses. They were as alike in behavior as any dogs we have found in the entire group of more than 40 studied They each behaved in the same manner toward the training process and the experimenter They responded regularly with vigorous reflexes, were eager to enter the laboratory, would fixate the pans, and behaved in every way that suggested a willingness to enter into the procedure There is no doubt from these experiments that animal 1301 is in a different class from her litter mates Possibly her extremely inhibitive nature has caused her to be dominated by the other four. There is nothing shown in their behavior, however, to indicate why differences in social reaction have been formed among them.

Following the above experiment, the laboratory was arranged so that each animal could be studied in association with every other one of the five A second food pan apparatus was added to the first one so the dogs could stand side by side for the signals and await the food. Each animal was then trained in the new position so that every one could be used in either the first or second position during the experiment Both pans were close enough to allow each dog to take food from either pan Two monometers were used, one connected with each animal, in order to record the responses separately The same conditioning signal, *M* 120, as used in the previous experiment, was used here All the dogs, except the female 1301, had already formed conditioned responses to this signal.

The main point of the experiment is whether each dog will respond in the same way it did in the first training when it finds itself in the presence of another animal, and if not, what variation from the first record will occur. The results have been put in tabular form in Table 2 The negative sign indicates that the dog's response was inhibited, or unfavorably disturbed by the presence of the second animal Each square in the table indicates how the dog numbered in the column at the left behaved in the presence of the dog numbered at the top of the other columns

TABLE 2

BEHAVIOR OF EACH DOG IN PRESENCE OF EVERY OTHER DOG OF THE GROUP

Number of dog	1301	1300	1298	1304	1297
1301	X	—	—	—	—
1300	Normal*	X	Normal	Normal*	Normal
1298	Normal*	—	X	Normal	—
1304	Normal*	—	Normal Eat from same pan	X	Normal
1297	Normal*	Normal	Normal*	Normal	X

*The dog numbered at the left ate the food of the dog numbered at the top.

It is seen from Table 2 that each dog behaved normally when in the presence of another one with the exception of three combinations. The female, 1301, which had never become adjusted to the laboratory environment and had been unable to form a conditioned response, was disturbed by the presence of each of the other dogs This animal crouched on the floor and became completely passive when any one of her brothers and sisters was present She made no attempt to take food or to stand near the pans. Although as a rule this animal was disturbed when in the room alone, she nevertheless would stand and move about. The presence of each of the other dogs brought on a complete inhibition similar to the behavior she exhibits in the run when they attack her The male, number 1298, was inhibited in the presence of male 1297, the dominant animal in the kennel Dog 1298 was also disturbed by the dominant female, 1300. The female 1304 was likewise inhibited by the dominant female, 1300. In every case the animal that was disturbed allowed the second dog to eat from his or her pan None of the dogs as effected by the presence of 1301, and each of them took her food as she stood passively aside making no protest

The dogs which were dominant and aggressive under the more natural conditions of the kennel exerted a disturbing effect on the respective dominated animals when under laboratory conditions This disturbance was indicated by inhibition of the conditioned response and by withdrawal from the food pan. The behavior is precisely that which takes place in the kennel. In the laboratory, however, we get a more accurate picture of what is happening, all the reactions involved in approaching the pan and eating are weakened or suppressed as the antagonistic withdrawal reactions arise.

It is possible that the above behavior may be due entirely to the previous associations formed among the dogs of the group Before determining whether the basic factor for dominance is constitutional or an experiential reaction, these dogs must be further studied in association with strange animals In a third experiment the five animals were brought into the laboratory with dogs from other litters, individuals that they had never met before In order to make the set-up comparable an extremely aggressive male and female should be used as well as dogs belonging to the shy or timid type. Among the trained dogs available there was one that had proven to be aggressive in any group This animal is a hybrid F_2 derived from two basset-shepherd F_1's. He is predominately shepherd in physical appearance and has always been a ruler in his group An extremely timid female was used, yet one that was not as timid as 1301 This bitch was also a basset-shepherd F_2 that has formed good reflexes but showed the passive defense attitude when approached by a strange dog A third animal, a pure bassethound, belongs to what we term the mid-group, that is, an animal that is neither extremely aggressive nor extremely timid. This dog would be called well balanced and a good experimental type It was impossible to find a female more aggressive than the one belonging to the group of five and for this reason a fourth animal was not used. The five litter mates were now studied in exactly the same manner as described above in the second experiment along with these three strange animals.

TABLE 3

BEHAVIOR OF EACH DOG IN THE PRESENCE OF THREE STRANGE DOGS

Number of dog	1528 Timid bass-shep	1152 Aggressive bass-shep	1426 Mid-group basset
1301	—*	—*	—*
1300	1st response negative 2nd normal	—*	Response partly inhibited
1298	Response normal	—*	Response normal
1304	1st response negative 2nd normal	—*	Response partly inhibited
1297	Response normal	* 1st response negative 2nd normal	Response normal

*Indicates that the dog numbered at the top of the column ate both pans of food.

Table 3 shows how the five dogs of the group, numbered in the left column, behaved in the presence of the two males and the female from the strange litters numbered at the top of the columns. If the responses were completely inhibited a negative sign is used. In some cases the first response was inhibited but not the second

The timid female of the group, 1301, was again completely inhibited in this experiment In each case the strange dog ate her food. She appeared extremely shy, and would crouch away from the accompanying dog. The dominant male, 1297, was disturbed and somewhat inhibited at first by the aggressive male, 1152, he withdrew while 1152 growled and nosed him The experimenter had to interfere in order to keep 1152 from attacking. This aggressiveness on the part of 1152 had an inhibiting effect on the first response of 1297. On the second application of the signal, however, 1297 gave a normal response, but even then he allowed 1152 to eat his food, withdrawing as soon as 1152 approached with a snarl It is recalled that animal 1297 would never withdraw in the presence of members of his own litter; for this reason it may be said that he was entirely dominated by 1152 Animal 1297 gave a normal response in the presence of the other two dogs, and in both cases took their food, while they withdrew on his aggression Neither 1528 nor 1426 responded normally, while 1152 gave a vigorous response in the presence of 1297 Animal 1300, the dominant female of the group, was also inhibited by 1152, but she was disturbed only for a short time in the presence of 1528 and 1426. This temporary disturbance seems to be a form of initial inhibition that lasts until the dog, in a sense, determines his status in the situation Animal 1300 would take food from the pan of 1426, but not from 1528. Both 1528 and 1426 gave a normal response, indicating that they were not diverted by the presence of 1300. The male, 1298, reacted normally with both 1528 and 1426, but was completely inhibited by 1152. The female, 1528, reacted normally in association with 1298, while the male, 1426, was entirely inhibited by 1298 The behavior of 1304 was quite like that of her litter group; she was also disturbed by 1152, and showed the initial inhibition in the presence of 1426 and 1528, which was overcome as the experiment progressed She would eat from the same pan with both of these dogs when she had finished her own food.

To summarize, we find that all the dogs in the group of five were inhibited by the extremely aggressive male, 1152, but that all of them, with the exception of 1301, reacted normally in the presence of the less aggressive strange dogs Both females, 1300 and 1304, showed an initial inhibition in association with the two timid dogs, while the aggressive male of the group, 1297, showed it only when with 1152

Discussion and Conclusions

In this series of experiments we have studied the effects of the presence of one dog on the behavior of another It is conclusive that the dogs which are dominant in a group under kennel conditions have a definite influence on the mental processes of the dominated animals when placed in the laboratory This is exemplified by the inhibition of the conditioned response and by a disturbance of the total food-taking reaction.

To determine whether such dominance and submission were due entirely to past association, the dogs were studied under identical conditions along with strange animals. Under these circumstances, *each dog readily recognized whether the stranger was a dog which* he could or could not dominate. The submissive animals withdrew immediately when the aggressive strange dog entered the laboratory. Dogs which were dominant within the group became submissive in the presence of strange animals which were more aggressive than themselves Thus the dog's behavior patterns are not governed solely by their past group associations, but are based on inherent characteristics. This is particularly shown by the fact that the extremely timid dog, 1301, and the extremely aggressive dog, 1152, have been distinguished by these qualities since early puppyhood.

Two such animals represent different extremes in social behavior. There is no doubt about their reactions. One is submissive while the other is dominating The other dogs of the litter group themselves between these two extremes and make adjustments to one another in a relative manner Possibly this relationship is based on differences in intensity of the behavior reactions. Basically, the social reaction involves withdrawal and approach reflexes The total behavior consists of a complex of reactions including both emotional and sensory motor phenomena. There is no doubt that the total behavior is initiated by facial expression, such as the snarl, expression of the eye, and ear position, by sound, as the nature of the growl; and by the mode of approach, that is, if the advance is brisk and erect, or crouched and hesitant. All of these factors are important in the immediate reaction of one dog to another The greatest conflicts occur among dogs that have the approach and withdrawal reactions nearly equal in intensity, and, as we have pointed out, the extremely shy animals never attempt the approach reaction, while the extremely aggressive animals remain so in every social situation

This general difference in intensity of the behavior seems to be correlated with the degree of purity of the excitable and inhibitible types. The extremely aggressive dog showed every characteristic of what has been termed a highly excitable dog by Pavlov. The shy dog had characteristics of the so-called inhibitible animal. Most of the dogs used in the present study fall between the two extremes and are well-balanced animals belonging to the mid-group It is recalled that four of the dogs from the litter of five were as nearly the same in behavior as any we have studied Differences were noticeable only when they were brought into the controlled social situation. This emphasizes the fact that the important factors in social behavior can be analyzed best only under the controlled association arrangements.

The initial inhibition shown by some of the dogs when they came into the presence of a second animal is a reaction of importance This hesitation is comparable to the defensive attitude so often observed in human experience. It is probably a basic protective phenomenon occurring during the interval necessary for estimating the aggressiveness or submissiveness of the opponent. This initial inhibition was not displayed on the part of the females when they approached the male dogs. Possibly this is due to the fact that the male, as a rule, does not attack the female.

The question may be raised as to the part played by physical strength and ability in social aggressiveness Many dogs with an intense social approach reaction are incapable of maintaining their supremacy in conflict with a larger dog. After defeat the first dog will be submissive toward his conqueror, but will continue his aggressive behavior toward other dogs It is in this manner that association modifies the reactions of a particular animal On the other hand, there are dogs which would be able to maintain supremacy in physical combat, yet will remain submissive because they will not engage in a fight. Here again the importance of constitution is emphasized.

The significance of constitutional type in social adjustment should be of interest to those investigating human social reactions. It is well known that there are aggressive, or extrovert, individuals and submissive, or introvert, individuals In human society one type is forced constantly to make adjustments to the other Some people made the adjustments easily, others fail entirely, and there are others in which adjustment is a difficult struggle not always apparent to the observer In these experiments animals which appeared to be at ease under the social conditions of the laboratory showed by inhibition in their conditioned response that some disturbance was present. There are many forms of neurosis in the human not due to obvious conflict, and a tension similar to that demonstrated here may be the basis for some of them A disturbing factor is always present in the case of individuals on the shy end of the scale In the case of animal 1301, the very timid dog, the nervous disturbance is complete and the dog cannot even attempt an adjustment. This dog cannot be classified as neurotic in the sense that her behavior is due to conflicts arising from forced adjustment. She is so constructed biologically that social adjustment is impossible. This then is constitutional and not a behavioral progression. Human individuals of this type are recognized without difficulty In the human, as in the dog, constitutional reactions and general type must be considered in analyzing all social behavior.

These experiments are offered as a lead to social studies with dogs. Studies on the different types of dogs may well aid in solving the problems of human nervous conditions.

SUMMARY

In developing a conditioned reflex animals have always been trained alone in a quiet isolated chamber. Would an animal so conditioned react the same if a second animal were placed in the chamber with him? Also would the effects on his nervous reactions be different when the second dog was an intimate companion or when a complete stranger? In other words, how is the nervous behavior of an animal affected simply by association with other individuals? The present experiments attempt to answer such questions.

1 In a litter of dogs, containing two males and three females, that had been kept together since birth, a definite order of dominance and submission was built up One female in the group was dominated by the other four litter mates and, among these four, a second female dominated the third female, and one male dominated the other male. The dominant female of the group did not take the aggressive against the males, but she did not allow them to dominate her.

2. When the dogs were trained individually in the conditioned reflex laboratory it was found that the dog which was dominated by the other four animals was unable to make an adjustment to the laboratory situation or to form a conditioned reflex The four

animals that dominated this female were able to form reflexes The behaviors of these four dogs, studied individually, were more nearly the same than any we have found among other dogs in the group of 40 that have been studied They fall into what has been termed a mid-group, or well-balanced animals, and are neither extremely excitable nor extremely inhibitible. The one female that was unable to form a conditioned reflex must be classed as extremely inhibitible

3 After the above training the dogs were studied in the laboratory, two at a time, until each one had been studied in relation to every other one It was found that each dominant dog had an inhibiting effect upon the individual that he dominated None of the animals was disturbed by the presence of the extremely inhibitible female, while she was greatly disturbed by each one of the other four

4 These five dogs were then studied in relation to entirely strange animals. For these companions one extremely aggressive male, a timid female, and a mid-group male were chosen It was found that the aggressive dogs of the group of five were themselves inhibited by the presence of the very aggressive male stranger The litter mates dominated by this stranger were still aggressive however toward the two less aggressive strange dogs.

5 It is postulated that extreme aggressiveness and shyness in social situations is correlated with excitability and inhibitibility as inherited constitutional factors.

6. This experiment emphasizes the importance of constitution in social adjustment in dogs When animals differ widely, there is no specific conflict between them · the one dominates, the other is subdued When animals are more or less equal in their social approach behavior, conflicts arise.

7 Studies of social adjustment among dogs of various constitutional types may be useful in interpreting certain social adjustment reactions in the human In these experiments excitable, inhibitible, and intermediate constitutions may be observed under controlled conditions

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LANGUAGE DIFFICULTY AND LEARNING THE RELATIVE EFFECTIVENESS OF A SERIES OF STUDY SHEETS OF GRADED DIFFICULTY AS TEACHING DEVICES WITH CHILDREN IN THE 6A GRADE*

From the Louisville Public Schools

MILTON B. JENSEN[1] AND MABEL SCHRODT[2]

INTRODUCTION

In a preliminary investigation (unpublished) the authors determined that five history books in common use in the sixth grades of the Louisville Public Schools, and an unpublished historical story of their own composition, differed markedly with respect to vocabulary difficulty, average sentence and phrase length, degree of comprehension with which they were read by sixth-grade children, and how much sixth-grade children learned from a five-minute study of representative selections from them. It was further apparent that what a child learns from a five-minute study period is not wholly dependent upon the above-named factors—comprehension, vocabulary difficulty, phrase, and sentence length In our opinion, style of presentation, key sentences, etc., are vital elements It seems to us that too much "story" may actually detract from learning and that study materials may be too "entertaining" to be good teaching devices where time is limited.

Our major investigation, as reported in this paper, is an evaluation of various degrees of difficulty of comprehension as affecting learning at the sixth-grade level Our findings indicate that, at this level, children learn about twice as much per unit of time from study material well within their range of comprehension as from the more difficult treatments they are frequently expected to master.

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I

A short selection about Arabia from Gibbon (1) was rewritten in such a manner as to form a series of five selections (including the original), uniform in content, but differing markedly in difficulty (See Appendix A). This particular selection was used because of a conviction that groups of sixth-grade children would be equally *unfamiliar with it when equated for age, achievement-, and intelligence-test scores.*

Thirteen experienced teachers rated the five selections as to the school grade they thought each fitted best. They were Principals of Elementary Schools, 2; Teachers of High School English, 5; Normal School Teachers of English, 1; Elementary School Supervisors, 2; Research Workers in Education, 1, Teachers of Social Science in Elementary Schools, 1. The ratings of the judges together with their means and standard deviations are given in Table 1. That the selections constitute a graded series is emphasized by the fact that in only two instances are the ratings otherwise: Judge *D* rated *Selections II* and *III* of equal difficulty, and Judge *J* rated

TABLE 1

RATINGS OF DIFFICULTY OF FIVE SELECTIONS BY THIRTEEN JUDGES
(Ratings Are in Terms of School-Grade Placement)

	Selections				
Judges	*I*	*II*	*III*	*IV*	*V*
A	13	10	7	4	3.5
B	14	9	8	5	4
C	10	9	8	5	4
D	12	11	11	7	3.5
E	12	9	7.5	7	4
F	11	9	6	5	4
G	10	9	6	5	3.5
H	11	10	7	6	3.5
I	11	9	7	6	3.5
J	12	7	8	6	3.5
K	11	9	8	5	3.5
L	12	10	8	6	4
M	12	8	6	5	3.5
Mean ratings	11.6	9.2	7.5	5.5	3.7
S.D.	1.08	.96	1.19	.85	23
Difference between successive means		2.4	1.7	2.0	1.8
P E $_{diff}$		.30	.32	.30	.18
Diff /P E $_{diff}$		8.0	5.3	6.7	10.0

TABLE 2

VOCABULARY ANALYSIS OF SELECTIONS COMPRISING GRADED SERIES OF STUDY MATERIAL
(Thorndike's Classification, Frequency of Usage)

	Selections									
	I		*II*		*III*		*IV*		*V*	
	Words	Percentage	Words	Percentage	Words	Percentage	Words	Percentage	Words	Percentage
1-500	43	34.8	62	46.9	103	56.9	185	67.4	102	61.8
501-1000	20	16.1	24	18.2	29	16.0	38	13.8	22	13.3
1001-1500	2	1.6	8	6.0	7	3.9	8	2.9	10	6.1
1501-2000	6	4.9	9	6.8	4	2.2	8	2.9	3	1.9
2001-2500	7	5.8	3	2.3	6	3.3	7	2.5	5	3.0
2501-3000	10	8.0	5	3.8	5	2.8	7	2.5	4	2.5
3001-3500	1	.8	1	.8	3	1.8	1	.4	1	.6
3501-4000	6	4.9	2	1.5	4	2.2	3	1.1	2	1.2
4001-5144	10	8.0	7	5.3	4	2.2	3	1.1	2	1.2
5145-5544	2	1.6	3	2.3	4	2.2	4	1.4	2	1.2
5545-6047	0	0.0	0	0.0	1	.5	1	.4	1	.6
6048-7262	1	.8	0	0.0	0	0.0	0	0.0	1	.6
7263-8145	4	3.1	2	1.5	1	.5	2	.7	2	1.2
8146-9190	0	0.0	0	0.0	0	0.0	0	0.0	1	.6
9191-10,000	2	1.6	1	.8	2	1.1	1	.4	1	.6
Beyond 10,000	10	8.0	5	3.8	8	4.4	7	2.5	6	3.6
Total words	124	100%	132	100%	181	100%	275	100%	165	100%
Mean sentence length (words)	27.1±1.8		23.4±1.3		11.9±.8		7.9±.5		10.4±.3	
Mean phrase length (words)	12.1±.8		10.3±.7		9.9±.6		6.9±.3		8.6±.3	

Selection III as more difficult than *Selection II*. The differences between successive mean ratings, the probable errors of these differences and the resultant quotients ranging from 5.3 to 10 0 are given in Table 2. That these selections actually are of the difficulty indicated by the ratings of the judges is, of course, questionable For the purpose of this study it is sufficient that they constitute a series of decreasing difficulty all containing the same, or about the same, data relative to Arabia that are given in the original It is quite evident, however, that our judges underestimate the difficulty of all the selections; they rated *Selection V* as of 3 7 grade difficulty, and yet the 6*A* children who studied this selection ten minutes (ample reading time) averaged only 30.36 of a possible 50 correct responses on the examination. Their failure to score higher on the test is probably due to the fact that *Selection V* (the easiest) is much more *difficult than is indicated by the mean rating of grade 3.7* by our 13 judges.

II

The five selections in the series were examined with respect to sentence and phrase length (five letters being counted as one word) and percentages of words falling in the various categories of Thorndike's classification (3). These data are given in Table 2 The general trend is for the easier selection to have shorter sentences and phrases, and to be composed of more frequently used words. That these situations are not altogether the case is not only interesting but substantiates our opinion that style of presentation is of vital importance in determining what an individual learns from what he reads (see Introduction) Leading, size of type, etc., were not factors in this situation, however, since all the selections were presented to the children in mimeographed form.

III

In selecting experimental groups, data were secured from 218 6*A* children in five elementary schools. From these, five groups of 25 were secured, each child in each group being paired with a child in each of the other four groups on the basis of age and test performance as measured by the Otis S-A Test of Mental Ability, and the Public School Achievement Test. The standard scores from these two tests were combined in making the pairings, and sex was disregarded. These procedures were considered permissible because of the relationship existing between the variables The basic correlations are given in Table 3.

TABLE 3

BASIC CORRELATIONS FOR DATA SECURED FROM 184 CHILDREN IN THE *6A* GRADE

	Age	Score Otis S A.	Score Public School Achievement	Otis+*P S A.* (Standard Scores)
Age		84± 045	—.404± 036	
Otis Test			836± 014	
Sex (biserial)				11± 02

TABLE 4

BASIC DATA FOR THE FIVE EXPERIMENTAL GROUPS EQUATED AS TO AGE AND SUM OF STANDARD SCORES ON OTIS SELF ADMINISTERING TEST OF MENTAL ABILITY AND PUBLIC SCHOOL ACHIEVEMENT

GROUP I

Student	Sex	Age	Otis score	P S A score	z_1+z_2*	Reading P S A	Score, test on Arabia
1	M	12-4	23	167	—1 49	21	9
2	M	13-3	43	234	1 33	56	21
3	M	11-3	43	272	2 02	58	21
4	M	12-7	35	210	25	38	17
5	M	13-2	22	150	—1 88	32	0
6	F	11-8	39	223	81	42	19
7	M	12-3	40	202	52	52	20
8	F	11-9	40	248	1 35	58	19
9	M	12-2	38	195	22	48	1
10	F	12-3	37	179	— .15	32	19
11	M	12-1	24	151	—1 70	31	16
12	F	13-4	48	195	1 03	49	18
13	M	12-0	34	196	— 08	37	3
14	F	11-8	46	224	1 39	38	19
15	M	11-4	34	195	— 10	29	13
16	M	11-1	39	261	1 49	59	12
17	M	11-4	30	182	— 65	33	9
18	F	11-5	60	280	3 53	62	32
19	M	11-6	34	212	21	44	27
20	M	12-7	57	259	2 91	60	23
21	M	12-10	17	133	—2 58	24	17
22	M	11-5	31	228	.26	49	7
23	F	11-8	50	254	2 25	48	16
24	M	11-11	47	240	1 76	56	23
25	M	11-4	32	182	— 49	40	11
Mean		12.0	37 72	230 9	.49	43.8	15 8
S.D		7 75 mo	10 2	38 1	1 46	11 8	9 1

*The standard scores were calculated from data secured from 184 *6A* children The means and standard deviations for the two tests were Otis S A M=35.6, S D =12 4, Public School Achievement, M=193 2, S.D.=55.6

TABLE 4*a*

GROUP II

Student	Sex	Age	Otis score	P S A score	z_1+z_2*	Reading P S A	Score, test on Arabia
1	F	12-5	23	187	—1.13	30	21
2	M	13-0	49	227	1.79	48	15
3	F	12-1	50	234	1.89	54	22
4	F	12-3	34	217	.30	40	20
5	F	13-4	15	123	—2.92	29	13
6	M	11-10	33	252	.85	37	6
7	F	12-4	40	212	.70	39	20
8	F	11-11	41	248	1.43	41	14
9	M	12-1	36	208	.30	42	9
10	M	11-10	25	219	.40	44	8
11	F	11-11	32	135	—1.32	30	16
12	[illegible]	13-2	41	229	1.08	38	20
13	M	12-1	35	197	.02	31	12
14	F	11-9	41	248	1.43	43	22
15	F	11-7	28	211	— .29	30	3
16	F	11-10	43	246	1.55	42	21
17	M	13-4	27	194	— .68	27	20
18	F	11-10	53	337	3.99	49	18
19	F	11-6	34	224	.42	43	18
20	M	11-10	56	254	2.73	50	28
21	M	11-11	21	131	—2.29	21	5
22	M	11-8	58	228	.27	40	25
23	F	11-8	46	274	2.29	55	27
24	F	11-6	42	235	1.27	51	26
25	M	11-4	30	192	— .47	31	17
Mean		12-1	37.2	214.5	.51	39.7	17.0
S D		6.65 mo	11.0	44.2	1.52	8.4	7.0

Data for the five experimental groups are given in Table 4. Original test scores as well as the sums of standard scores on the two tests are given in the table. In pairing the children it was found more convenient to combine standard scores on the two tests, using means and standard deviations for the 184 children comprising the original group. That this procedure is justified is shown by the close relationship between scores on the two tests and for our 184 children ($r=.836\pm.014$). Corrected for unreliability and age differences this is so close to unity, as shown by Kelley (2), that the tests may be thought of as measuring nearly identical elements and, consequently, scores on them may be combined in an additive manner. That these groups are well equated will be seen from inspection of

TABLE 4*b*

GROUP III

Student	Sex	Age	Otis score	P S A score	z_1+z_2*	Reading P.S A	Score, test on Arabia
1	F	12-2	23	165	—1 53	31	13
2	M	13 1	38	233	91	58	27
3	M	11-8	51	231	1 92	54	29
4	F	13-2	37	177	— 18	52	27
5	M	12-5	58	279	—2 16	49	6
6	M	12-9	42	207	77	47	19
7	F	11-5	32	206	— 06	47	17
8	F	11-9	43	231	1 25	34	17
9	F	12-2	34	194	12	44	14
10	F	12-3	33	190	— .27	47	26
11	M	12-4	24	131	—2 06	33	16
12	F	13-3	42	196	.57	45	17
13	F	12-3	37	175	— 22	47	23
14	F	12-0	53	241	2.26	52	35
15	F	11-6	40	164	— 16	28	13
16	F	11-2	46	204	1.03	44	24
17	F	12-1	31	164	— 89	24	10
18	F	11 8	66	268	3 80	49	28
19	M	11-4	38	210	.49	46	19
20	M	12-2	59	245	2.82	52	50
21	M	11-8	56	243	—2.54	59	36
22	M	11-8	38	215	.58	52	27
23	F	11-8	53	233	2 12	49	9
24	M	11-7	49	229	1 72	59	23
25	F	11-7	31	189	— 44	51	17
Mean		12-0	41 6	204 8	39	46 1	20 5
S. D.		6 7 mo	10 8	35 0	1 53	8 6	7 6

Table 5 Differences between mean ages and mean test scores (the sum of standard scores for the two tests) are given The probable errors of the differences between means and the resultant quotients are also given.

IV

Each of the experimental groups was given one of the study sheets (Appendix A) to study for ten minutes, Group I has *Selection I*, Group II, *Selection II*, etc The instructions given below were uniform for all groups:

> You will have ten minutes in which to learn all you can from the selection below Study it carefully Learn everything you can from it Do not waste any time *At the end of ten minutes*

TABLE 4c

GROUP IV

Student	Sex	Age	Otis score	P.S A score	z_1+z_2*	Reading P.S.A	Score, test on Arabia
1	F	11 8	41	227	—1.41	50	18
2	M	11-9	36	182	.57	55	22
3	M	11-7	51	257	2 40	49	32
4	F	12-2	30	223	.14	52	25
5	M	11-9	27	157	—1 34	23	17
6	M	11-6	46	198	93	39	37
7	F	12-6	44	202	.84	45	33
8	F	11-8	27	153	1 05	30	24
9	F	11-9	36	198	12	43	16
10	F	12-6	38	188	30	43	18
11	F	12-1	25	142	—1 78	40	20
12	M	11-5	43	201	74	42	20
13	M	11-10	36	182	.17	34	12
14	F	11-6	43	228	1 23	47	23
15	F	11-6	38	176	12	32	21
16	F	11-3	40	258	1.53	59	28
17	M	12-1	36	151	— .73	33	29
18	M	11-5	53	296	3 25	58	30
19	F	11-6	28	197	28	39	27
20	M	11-11	40	205	2.84	55	35
21	F	11-6	20	155	—1 95	21	21
22	F	11-7	42	184	35	36	25
23	F	11-7	57	249	2 73	62	37
24	F	11-9	47	223	1.46	53	33
25	F	11-7	37	178	.16	32	27
Mean		11-9	38 24	200 4	.50	42 7	25 2
S D.		3.76 mo	8.9	38 1	1 37	10 9	6 8

> the study sheet is to be handed in and you will be given an examination to see how much you have learned

At the end of the ten-minute period the study sheets were collected and the same examination (Appendix B) was given to all the children in all the groups. It was the intent of the authors that this examination test for all the major facts contained in the original selection (No. I, Appendix A). Scores for each child in each group as well as group averages and standard deviations are given in Table 4. Test reliabilities, by the split-score method, using the Spearman-Brown formula, were found to be as in Table 6.

TABLE 4*d*

GROUP V**

Student	Sex	Age	Otis score	P S A score	z_1+z_2*	Reading P S A	Score, test on Arabia
1	M	12-3	27	156	—1.58	33	24
2	M	11-6	46	197	75	39	34
3	F	11-5	51	229	1 73	47	34
4	F	12 7	36	215	08	39	35
5	F	12 3	33	173	— 79	34	27
6	M	11-5	53	215	65	42	39
7	F	12-1	40	217	53	39	31
8	F	11-5	45	229	1 25	39	35
9		12-9	27	215	.24	38	19
10	M	11-8	17	201	— 13	35	26
11	M	12-2	19	173	—1 93	30	19
12	M	11-6	43	229	1 09	42	30
13	F	11-10	35	215	02	42	31
14	M	11-9	48	217	1.18	37	39
15	M	12-9	29	215	— 48	36	26
16	F	11-5	46	236	1 60	49	35
17	F	11-7	30	189	— .68	33	22
18	M	11-0	59	262	2 98	47	45
19	M	11-2	37	217	29	30	30
20	M	11-9	53	221	1 74	39	37
21	M	12-3	18	148	—2 42	32	18
22	M	11-8	37	197	02	39	31
23	M	12-1	44	217	87	42	25
24	M	12-2	45	201	.76	39	36
25	F	11-8	37	197	02	36	31
Mean		11-10	38 3	207 4	28	38 3	30.36
S.D.		3 5 mo	11 1	25 9	1 22	4 9	5.32

**Public School Achievement Test scores for Group V were estimated from scores on the Metropolitan Achievement Tests, Intermediate Battery This was done by using age and grade norms for the two tests Incomparabilities in the norms of the two tests, of course, are present in the estimated test scores.

From Table 4 it will be seen that Group V scored almost twice as much after ten minutes of study of *Selection V* (the easiest) as Group I scored after ten minutes of study of *Selection I* (the hardest). The differences between means for the various groups together with probable errors of these differences and resultant quotients are given in Table 7.

TABLE 5

STATISTICAL ANALYSIS OF DIFFERENCES BETWEEN MEANS FOR THE FIVE EQUATED GROUPS

Group	Diff.	Age P.E.$_{diff}$	Diff/P E $_{diff}$	Standard Scores (Otis S A + Public School Achievement) Diff	P E $_{diff}$	Diff /P.E $_{diff}$
M_1—M_2	1 mo	1 40 mo	71	,02	29	07
M_1—M_3	0 mo.	1,44 mo.	00	05	290	,18
M_1—M_4	3 mo	1 13 mo	2 68	,01	,280	03
M_1—M_5	2 mo	128 mo	1 56	21	26	81
M_2—M_3	1 mo.	1 35 mo	,75	,07	30	24
M_2—M_4	4 mo	1 00 mo	4 00	01	,29	03
M_2—M_5	3 mo.	1 15 mo	2 61	23	27	85
M_3—M_4	3 mo.	1 05 mo.	2 83	06	28	,21
M_3—M_5	2 mo	1 10 mo.	1 82	,11	27	41
M_4—M_5	1 mo	,80 mo	1 25	03	25	12

TABLE 6

Group	r_{11}
I	.837
II	860
III	.844
IV	.734
V	.765

TABLE 7

STATISTICAL ANALYSIS OF SCORES ON TEST ON ARABIA BY FIVE EQUATED GROUPS

Differences between means	Diff	P E $_{diff}$	Diff./P E.$_{diff}$
M_1—M_2	1.20	1,56	77
M_1—M_3	4 62	1 62	2 85
M_1—M_4	9,36	1 56	6 00
M_1—M_5	14 52	1 44	10 09
M_2—M_3	3 41	1 40	2 46
M_2—M_4	8 16	1 32	6 17
M_2—M_5	13 32	1 19	11 21
M_3—M_4	4 72	1,39	3 39
M_3—M_5	9,88	1 27	7 86
M_4—M_5	5,16	1 18	4,37

SUMMARY AND SUGGESTIONS

1 Difficulty of comprehension, type used, sentence and phrase length, and method of presentation are vital elements in study sheets at the sixth-grade level.

2 Of our equated groups, the one studying the easiest selection learned approximately twice as much in a ten-minute period as did the group studying the most difficult selection.

3 Those responsible for the adoption of textbooks should ascertain that the books are good teaching devices before they approve their purchase It would not be unreasonable to require of publishers proof from reliable research sources that a text is a good teaching device before its adoption is even considered.

4 Publishers of textbooks would do well to determine the effectiveness of teaching devices before accepting them for publication.

APPENDIX A

Selection I (*Mean rating,* 11 6 *grade*) In the vacant space between Persia, Syria, Egypt, and Ethiopia, the Arabian peninsula may be conceived as a triangle of spacious but irregular dimensions From the northern point of Beles on the Euphrates, a line of 1,500 miles is terminated by the straits of Babelmandel and the land of frankincense About half this length may be allowed for the middle breadth, from east to west, from Bassora to Suez, from the Persian Gulf to the Red Sea The sides of the triangle are gradually enlarged, and the southern basis presents a front of 1,000 miles to the Indian Ocean The entire surface of the peninsula exceeds in a fourfold proportion that of Germany or France, but the greater part has been justly stigmatized with the epithets of the stony and the sandy Even the wilds of Tartary are decked by the hand of nature with lofty trees and luxuriant herbage, and the lonesome traveller derives a sort of comfort and society from the presence of vegetable life But in the dreary waste of Arabia, a boundless level of sand is intersected by sharp and naked mountains; and the face of the desert, without shade or shelter, is scorched by the direct and intense rays of a tropical sun

Selection II (*Mean rating,* 9 2 *grade*) In the open space between Persia, Syria, and Ethiopia, the Arabian peninsula may be thought of as a triangle or three-cornered piece of land, of wide but uneven measurements From the northern points of the city of Beles on the Euphrates river, a line of 1,500 miles is ended by the straits (long, narrow strip of water) of Babelmandel and the land of Persia About half this length may be allowed for the middle width, from east to west, from the city of Bassora to the city of Suez, from the Persian Gulf to the Red Sea The sides of the triangle slowly increase in length until the southern side has a sea coast of 1,000 miles on the Indian Ocean

The entire land area of the Arabian peninsula is more than four times that of Germany or France, but the far greater part has been rightly marked with the names of stony and sandy. Even the wilds of the country of Tartary in Russia are covered by the hand of nature with lofty trees and abundant pasture lands. The lonesome traveller receives a sort of comfort and society from the presence of this vegetable life. But in the dreary waste of Arabia, an endless level of sand is cut by sharp and barren mountains. The surface of the desert, without shade or shelter, is scorched by the direct and burning rays of a tropical sun.

Selection III (*Mean rating, 7.5 grade*). The countries of Persia and Syria in Asia, and Egypt and Ethiopia in Africa, come together in such a way as to form a large open space. This large space is filled by a great three-cornered piece of land called the Arabian peninsula. The lines which mark the boundaries of the Arabian peninsula are long and irregular. They spread wide apart to form a great triangle. The longest side of which is 1,000 miles long. This lies along the coast of the Indian Ocean.

If you begin at the northern part of the city of Beles on the Euphrates river and draw a line 1,500 miles long to a narrow strip of water called the straits of Babelmandel, you will have reached the country of Persia. This is the entire length of the great peninsula. To measure the width from east to west, begin at the city of Bassora and draw your line to the city of Suez, or you may measure from the Persian Gulf to the Red Sea. You will find that both of the east-west lines are about half as long as the line which measured the length of the Arabian peninsula.

The entire surface of the Arabian peninsula is more than four times the size of Germany or France. Unlike these countries, however, most of the land of Arabia is a dreary waste of sand. For this reason people consider it a very unpleasant place and have given it the names of sandy and stony. It stretches away in what seems to be an endless level of sand. But if you could fly over this desert, you could see that the long stretches of sand are cut by sharp, bare mountains. These mountains seem to rise directly out of the sand.

In the wild uncultivated lands of Tartary in Russia, a traveller will journey through tall trees and wide grass lands. The green of the forests and pastures make the traveller very comfortable for he feels that they are his friends. In Arabia, however, he must journey in great discomfort over endless sand. The rays of the sun fall almost straight down and scorch his skin for he is near the Tropic of Cancer which marks the northern boundary of the Torrid zone.

Selection IV. (*Mean rating, 5.5 grade*). The plane left the sea and started over the land. Down below lay a great three-cornered piece of land.

"What are we passing over now?" asked the boy.

"That large piece of land below you is Arabia. Look closely and you can see that it has three sides like a great triangle," answered the pilot.

"Yes, I can see the long sides stretching farther and farther, and all the time getting farther and farther apart. One side seems much longer than the other two."

"That is the southern sea coast. It borders on the Indian Ocean and is a thousand miles long."

"The land of Arabia seems to be almost surrounded by water."

"It is, and for that reason is called a peninsula—the Arabian peninsula."

"What are those countries which almost surround Arabia?"

"Persia, Syria, Egypt and Ethiopia. They form a sort of half circle with an open space in the center. The Arabian peninsula lies in the open space"

"How long is it across the entire peninsula?"

"Wait until I come nearer to earth and I'll show you. Now, see that place below you on the river? That is the city of Beles It is on the Euphrates river If you stretch a line from Beles to Persia, you will have a line 1,500 miles long"

"Where is Persia?"

"Down at the far end of the peninsula."

"I can see a narrow strip of water there."

"That is the strait of Babelmandel."

"How wide is Arabia?"

"You may measure it from two places Measuring from the city of *Bassora to the city of Suez, it is almost half as wide as it is long If you* measure from the Persian Gulf to the Red Sea, you get almost the same distance—750 miles Arabia is four times as large as Germany or France."

The ship left the coast and headed out over the great Arabian desert

"We are now traveling over the "Land of rocks and sand," said the pilot

"Why rocks? I see only miles and miles of sand which seem to run on forever."

"Before the use of planes many people found the desert a very unpleasant place to cross. Because of its endless sand and rocky mountains, and scorching sun, they marked it with stony and sandy To many it still seems a place of evil"

"I *think I see something moving down there*"

"You do That is a traveller, or he may be a merchant returning to his home"

"How long will it take him to cross the desert?"

"About sixteen days"

"Sixteen days! In that sun!"

"All of it and there is not one bit of shelter or food on the desert"

"Won't he and his camels die of the terrible heat?"

"Terrible is right, but he carries water with him. We are in the Torrid zone just south of the Tropic of Cancer."

"What does the Tropic have to do with the sun?"

"It marks the northern boundary of the Torrid zone and the rays of the sun fall directly upon your head Don't you see how short the shadows are?"

"I thought that the sand went on forever but I see something sticking up from the sand that breaks the long level line."

"Mountains We will fly over them in a few minutes and you can see how bare and sharp they are. If the mountains did not break that long stretch of sand it would go on for many, many miles more"

"Is all this land below good for anything?"

"Not a thing Nothing will grow there Nothing can live long there"

"Don't the natives have flocks?"

"Not in this part of Arabia"

"Is everything in this part of the world sandy and stony?"

"Oh, no To the north lies Tartary in Russia Even in most uncivilized parts you can see tall trees and great pastures of grass."

"It must be quite different crossing Tartary."

"The journey is quite pleasant After a time on a desert the plants and growing things seem like friends One forgets how tired he has been. When we reach the strait of Babelmandel we will fly north and let you see the country."

Selection V. (*Mean rating,* 3 7 *grade*) Far away in that part of the world known as Asia there is a country called Arabia (a-ra′ bi-a). Arabia is a great three-cornered country four times as big as France or Germany It looks like a great triangle on the map because it has three corners and three sides The three sides of this triangle are crooked They are not the same length and stretch far apart. The longest side of Arabia is 1,000 miles This is the southern side along the Indian Ocean.

Arabia is called a peninsula because it has water almost all the way around it At the northwest end of the Arabian peninsula is the country of Syria Persia, the land of spices, is to the southeast Across the Red Sea to the west are Egypt and Ethiopia These four countries—Syria, Persia, Egypt, and Ethiopia make a half-circle around Arabia.

The best way to measure the length of Arabia is to begin at Beles, a city in the northern part of Arabia. It is built on the banks of the Euphrates river From Beles go down the whole length of Arabia to the end of Persia at a long narrow strip of water This strip of water is called the Strait of Babelmandel From Beles to the Strait of Babelmandel is 1,500 miles.

There are two ways to measure the width of Arabia from east to west. One way is to begin at the city of Bassora and measure across to the Suez Canal The other way is to measure from the Persian Gulf on the east to the Red Sea on the west Either way the distance across Arabia from east to west is about 750 miles. This is just half as far as the distance from north to south

People think Arabia is an evil place and call it the "Land of Sand and Stones" In the desert of Arabia there is nothing but miles and miles of sand and stone. In some places sharp, bare mountains stick up through the sand like great teeth.

There is not a tree nor a bit of water on this desert. Arabia is in the Torrid zone or hot part of the world. It is just south of a line called the Tropic of Cancer In Arabia the sun shines almost straight down and is burning hot all day.

The land of Tartary in Russia is not at all like Arabia. Tartary is a land of green, growing plants. In Tartary there are tall trees and fields of grass Travellers who cross the Arabian peninsula sometimes die of heat and thirst, but travellers in Tartary have pleasant journeys. They are helped by all the green things that grow around them.

APPENDIX B

EXAMINATION ON ARABIA

Name . . . . School . . . .
Date . . . . . Grade . . . .

Directions: In each of the questions below underline the part that makes the best answer and write its letter in the blank space at the left, as in the following example:

Example:

b 1. Louisville is (a) a country (b) a city (c) a peninsula (d) a province

Answer all the questions!

------ 1 Arabia is (a) a state (b) a cape (c) a peninsula (d) an island (e) a group of countries

------ 2 The sides of Arabia make a sort of (a) square (b) triangle (c) circle (d) rectangle (e) half circle

------ 3 The width of Arabia is about (a) 500 miles (b) 100 miles (c) 250 miles (d) 750 miles (e) 1,000 miles

------ 4 The southern sea coast of Arabia is (a) 50 miles long (b) 1,500 miles long (c) 1,000 miles (d) 2000 miles (e) 750 miles

------ 5 The lines that make the great triangle of Arabia are (a) close together (b) far apart (c) make a circle (d) make a square (e) all end at the Persian Gulf

------ 6. Beles is on (a) a river (b) a gulf (c) a bay (d) a sea (e) an ocean

------ 7 The width of Arabia may be measured from (a) Bassora to Suez (b) Suez to Beles (c) the Red Sea to the Indian Ocean (d) The Euphrates to the Tigris (e) Bassora to Persia

------ 8 The Southern sea coast of Arabia lies on (a) the Atlantic Ocean (b) the Indian Ocean (c) the Pacific Ocean (d) the Persian Gulf (e) the Red Sea

------ 9. The distance from Bassora to Suez is the same as from (a) Egypt to India (b) France to Russia (c) Beles to Babelmandel (d) Beles to the Red Sea (e) Persia to the Strait of Babelmandel

------10 Arabia is about (a) one half as large as Germany (b) one fourth as large as Germany (c) four times as large as Germany (d) eight times as large as Germany (e) five times as large as Germany

------11 The name sandy and stony means (a) unpleasant (b) wicked (c) large (d) hot (e) dry

------12 The land of Tartary is (a) covered with sand and stones (b) filled with mountains (c) a pleasant place of trees and pastures (d) a land of bare fields (e) a land of burning heat

------13. The travelers in Tartary are rested by the (a) tall trees (b) flocks of sheep (d) the springs (e) the mountains

------14. The desert of Arabia is (a) a good place to live (b) a good place to raise flocks (c) a poor place to raise anything (d) a poor place to get sunburned (e) a good place to find gold

------15 The long stretches of sand in Arabia are broken by (a) rivers (b) fields (c) caravans of camels (d) travellers (e) mountains

------16 The mountains of Arabia are (a) tall and beautiful (b) bare and rocky (c) covered with sand (d) snow capped (e) covered with clouds

------17 Merchants on the desert (a) drink at the springs (b) carry their water (c) stop at the rivers (d) rest in the shade (e) travel at night

------18 The sun on the desert (a) makes long shadows (b) short shadows (c) no shadows at all (d) makes shadows only at noon (e) makes shadows when one gets near the mountains.

------19 The sun of Arabia is (a) warm (b) comfortable (c) burning (d) behind a cloud (e) not warm enough.

------20 The sun of Arabia shines in the (a) Torrid zone (b) South Temperate zone (c) South Frigid zone (d) North Frigid zone.

------21 The width of Arabia can be measured in (a) two ways (b) three ways (c) five ways (d) only one way (e) not at all.

------22 The longest side of Arabia is (a) on the ocean (b) the sea (c) the Euphrates river (d) the Persian Gulf (e) on the side toward Syria.

------23 Persia, Syria, Egypt and Ethiopia (a) make a triangle (b) a square (c) a circle (d) make a half circle with a space between them (e) make the land of Tartary

------24 Babelmandel is a (a) city (b) river (c) strait (d) ocean (e) country

------25. Arabia lies in the space between (a) Russia and India (b) Tartary, India and Palestine (c) Syria, Egypt, Persia and Ethiopia, (d) Syria, Egypt, Russia, and India (e) Egypt, Ethiopia, China and Beles

------26 The width of Arabia is (a) one half as long as its length (b) twice as long as its length (c) four times as long (d) three times as long (e) one fourth as long as its length

------27. The lines which form the great triangle of Arabia are (a) long and close together (b) short and even (c) uneven and far apart (d) curved and broken (e) short and close together

------28 Beles is on the (a) Tigris river (b) Euphrates river (c) Ohio river (d) Red Sea (e) Indian Ocean

------29 The distance from Bassora to Suez is the same as from (a) Egypt to India (b) France to Germany (c) Beles to Babelmandel (d) Beles to the Red Sea (e) Persian Gulf to the Red Sea.

------30 Arabia is about (a) as large as France (b) as large as the United States (c) four times as large as France (d) one fourth as large as France (e) as large as France and Germany together.

------31. The name sandy and stony has been given to Arabia because (a) it is thought to be a disagreeable place (b) there is no water anywhere (c) travellers die on the desert (d) there are no trees on the desert (e) no one knows anything about it.

------32 The land of Arabia is (a) deep and fertile (b) good for almost nothing (c) valuable for its palm trees (d) a good place to raise camels (e) a good place to make journeys

------33 The mountains of Arabia (a) break the long stretches of sand (b) pile up the sand (c) make a place to land airplanes (d) make a pretty view (e) shut out travellers from the desert.

------34 Travellers on the desert (a) rest in the shade at noon (b) stop at huts to rest (c) fill their water bottles every evening (d) eat figs as they walk along (e) must endure the hot sun all day.

------35 A traveller on the Arabian desert finds that the sun shines almost straight upon his (a) legs (b) head (c) back (d) arms (e) chest

------36. The sun of Arabia is (a) warm and pleasant (b) bright and burning (c) always behind a cloud (d) only shines a little while each day (e) not warm enough to be comfortable

------37. The width of Arabia may be measured from (a) the city of Beles to the Indian Ocean (b) Asia to Africa (c) Bassora to Suez (d) Euphrates to Tigris (e) Red Sea to the Persian Gulf.

------38 The longest side of Arabia is the (a) northern (b) eastern (c) southern (d) western.

------39 Persia, Syria, Egypt, and Ethiopia (a) make an island (b) make a peninsula (c) make a continent (d) make a long chain of land (e) make a sort of half circle with an open space in the center

------40 Babelmandel is (a) an isthmus (b) a strait (c) a sea (d) a river (e) a canal

------41 Arabia lies in a space near (a) America (b) Europe (c) Asia (d) Australia (e) China

------42. The names of sandy and stony have rightly (a) given fame to Arabia (b) marked it with disgrace (c) branded it with superstition (d) named it the land of herbage (e) marked it as a sacred land

------43. Much of the land of Arabia is (a) used for dumping (b) unfit for life (c) covered with stones (d) well watered (e) laid to waste by war

------44 A traveller on the desert of Arabia could (a) rest in the shade at noon (b) sleep under a plane tree (c) make himself a hut of cactus (d) eat dates for food (e) be protected from the sun *only at night*

------45 The sun of Arabia is near (a) the Pope's line (b) Tropic of Cancer (c) International Date Line (d) Arctic Circle (e) Antartic Circle.

------46 The distance between Beles and the straits of Babelmandel is (a) 1,500 miles (b) 1000 miles (c) 5000 miles (d) 100 miles (e) 2,500 miles.

------47. The distance from the city of Bassora to the city of Suez is about (a) 500 miles (b) 700 miles (c) 750 miles (d) 1000 miles (e) 100 miles

------48 The names sandy and stony have been given Arabia because (a) people dislike it (b) no one could cross it (c) for miles there is nothing but sand (d) it is covered with large stones (e) there are mountains on it

------49. The mountains of Arabia (a) break the long stretches of sand (b) pile up the sand (c) make the sand look like waves (c) water large areas with their snows (e) make a good place to hide

------50 A traveller on the Arabian desert could get protection from an umbrella if he could hold it (a) at his back (b) in front of him (c) at his right side (d) at his left side

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Louisville
Kentucky

SHORT ARTICLES AND NOTES

BLOCK MODELS

Marie L H Forbes

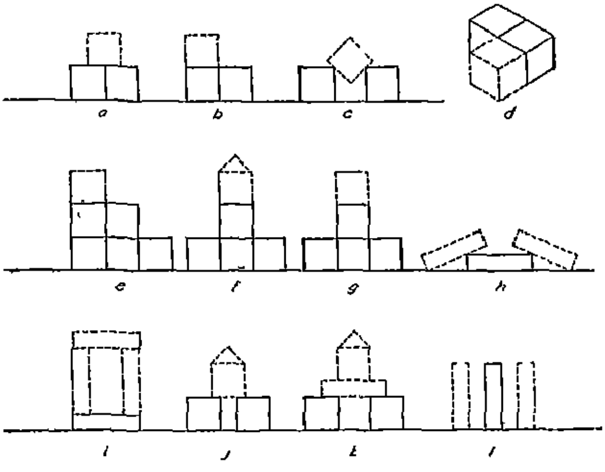
The drawing *shows models to be presented in succession in an exercise* in replacing missing blocks, indicated by dotted lines, on a foundation when a complete model is displayed beside it The first model is the bridge used by Gesell (1)

Following training which included the fitting of several blocks in a single hole cut to a pattern and the replacing of missing blocks on the final and only incomplete model in a row of models all of which were alike, the exercise was carried out with a boy having non-hereditary mental deficiencies, three and one-half years of age Model *d* was *repeated as the child threw the blocks when the model was first presented*

The following is a record of the time required to complete each model

Model	a	b	c	d	e	f	g	h	i	j	k	l
Seconds	5	6	4	7	11	7	8	11	20	30	20	25

The writer gratefully acknowledges the examination of the materials by her former instructor, Dr, Walter F Dearborn, Director of the Psycho-Educational Clinic, Harvard University



All cubes 1" - Oblong blocks ½ × 1 × 2

FIGURE 1

REFERENCE

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Cambridge, Massachusetts

A DIFFERENTIAL BASED ON THE DEARBORN COLOR-FORM TEST

MARIE L. H FORBES

Figure 1 shows a device of four cardboard discs graduated in size, fastened together in the center in a manner which permits a child to rotate them independently but not to spin them, on which are displayed 16 colored forms, four of each shape and color

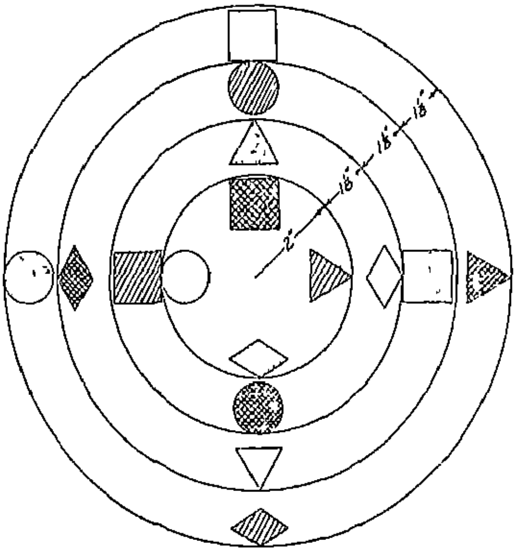

FIGURE 1

Figure 2 shows the same forms applied to cubes which are to be rotated on a rod

The differential is based on the Color-Form Test by Dr Walter F Dearborn (1, 2) in which "when the child is picking out forms he must disregard color and *vice versa*"

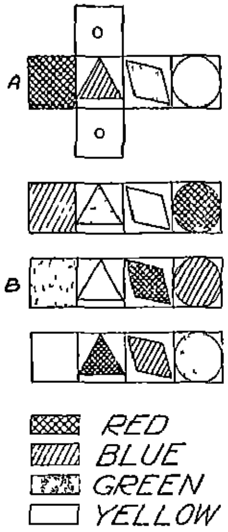

FIGURE 2

The writer gratefully acknowledges the examination of the materials by her former instructor, Dr Walter F Dearborn, Director of the Psycho-Educational Clinic, Harvard University.

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Cambridge, Massachusetts

THE EFFECT OF BAROMETRIC PRESSURE ON NOCTURNAL MOTILITY[1]

JAMES PAGE

An intimate relationship between weather conditions and human behavior has been suggested by several investigators (1, 2). In recent years

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[1] We are indebted to Dr C O Cheney and Dr S E Katz for providing hospital facilities and subjects.

Petersen (5) has offered a physiological basis for this interrelation The central theme of his explanation is that changes in the air mass require prompt autonomic adaptations. As a consequence of these autonomic reactions to atmospheric conditions, certain physiological changes occur, which changes are important factors in the production and precipitation of both physical and mental diseases.

In his writings Petersen particularly emphasizes the importance of barometric pressure, suggesting that manic attacks are associated with low barometric pressure (6) Savage's (9) work tends to support this observation. In a study of first admissions to a psychiatric receiving hospital, she found a slight excess of manic admissions on those days when the barometric pressure was low.

In more limited but more rigidly controlled experimental work, the effect of atmospheric conditions has been found to be less marked than might be expected from the above more general studies Both Pratt (7) and Renshaw (8) *et al.* found that neither temperature nor humidity have any appreciable effect on human motility.

PRESENT STUDY

In order to supplement the above temperature and humidity studies we have investigated the effect of barometric pressure on nocturnal motility.

SUBJECTS

In the present study we have recorded the motility of four women all in their early twenties. Each subject was studied for from 47 to 58 nights Since the amount of activity an individual engages in during a night is dependent upon his hour of retirement and the nature of his activities during the day, we attempted to standardize daily conditions by utilizing patients hospitalized at the New York State Psychiatric Institute and Hospital Three of the subjects were high grade morons employed in the hospital laundry while the remaining subject was a behavior problem case None of the subjects presented any marked physical or mental difficulties.

EXPERIMENTAL PROCEDURE

Motility records were obtained by kymographically[2] recording the bed-spring movements occurring from the time the subject retired for the night (9 00 P M) to the time she arose (6'00 A M.) A detailed description of how the motility scores were obtained has already been reported in an earlier study (4). Briefly we divided each of the nine hours into 12 five-minute intervals. The motility scores were based on the number of five-minute intervals in which some movement occurred. We obtained two measures of motility which may be designated as "Total Moves" and "Major Moves." "Total Moves" included the sum of all five-minute intervals in which there occurred at least one movement as great or greater than the quick movement of a forearm. "Major Moves" included the sum of the five-minute intervals in which there occurred a vigorous movement involving the entire trunk. According to this scoring method the "Major Moves" score is included in the "Total Moves" score.

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[2] The kymographs were those devised by Dr H. M. Jonhson (3) We are indebted to Dr. Johnson for the loan of the apparatus and for his helpful suggestions.

Barometric pressure readings were obtained from the United States Weather Bureau of New York City and were based on readings recorded at two-hour intervals from 8.00 P.M. to 6.00 A.M. of the following day. With respect to Table 1, the barometric pressure reading was obtained by averaging the six readings recorded every two hours during the night and the change in barometric pressure score was obtained by substracting the lowest of the six nightly readings from the highest.

RESULTS AND CONCLUSIONS

The present findings with respect to the effect of barometric pressure and barometric swings are summarized in Table 1. It is quite apparent that *neither barometric pressure nor barometric swings have any effect on* the motility of any of the subjects.

TABLE 1

THE EFFECT OF BAROMETRIC PRESSURE ON NOCTURNAL MOTILITY

		r* Mean barometric pressure and		r* Swings in barometric pressure and	
Subjects	No. *nights*	Major *moves*	Total *moves*	Major *moves*	Total *moves*
Sch	58	—0.02	+0.03	+0.02	—0.08
Yun	56	—0.12	+0.04	—0.10	+0.12
Yov	47	—0.19	—0.19	+0.08	+0.03
Car	54	+0.06	—0.04	—0.07	+0.14
Average		—0.07	—0.04	—0.02	+0.05

*P.E. for all correlations is ±0.09.

The correlation coefficients between "Total Moves" and barometric pressure range from —0.19 to +0.04 with an average of —0.04. The correlation coefficients between "Total Moves" and barometric swings range from —0.08 to +0.14 with an average of +0.05. The correlation coefficients between "Major Moves" and the two barometric readings are equally low. For all correlations, the P.E. is ±0.09 which means that not one of the 16 correlation coefficients approaches statistical significance.

In conclusion, we may state that barometric pressure plays a negligible rôle in human motility as measured in the present study Combining this finding with those of other investigators (7, 8), we may conclude that neither barometric pressure, room temperature nor room humidity appear to have any demonstrable effect on human motility

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THE INTELLIGENCE OF TWINS

RUTH BYRNS AND JAMES HEALY

Among the 119,850 pupils in Wisconsin high schools who were given an intelligence test during the school years of 1933-1934 and 1934-1935, there were 412 pairs of twins Of this number of 307 pairs were like-sex and 105 pairs were unlike-sex, 184 pairs of the like-sex twins were girls and 123 pairs were boys.

Since this was such a large number of intelligence test scores for twins it was thought that it might prove of interest to compare the mental ability of these 412 pairs of twins with the normal intelligence of high school students and also to determine how closely the twins resemble each other in mental ability.

The data on which this investigation of the intelligence of twins is based are a part of the material collected by the Wisconsin Cooperative Testing program in which the sophomores and seniors in all the public and private secondary schools in the state are given an intelligence test each year The total of 119,850 pupils who were tested represents approximately the entire high school population for the year 1933-1934 since the sophomores and the seniors were included for two succeeding years. The Henmon-Nelson Test of Mental Ability, Grades 8-12, Form *A* in 1933-1934 and Form *B* in 1934-1935, is the test which was used and the raw scores were converted into percentile scores

The distribution of percentile scores in the intelligence test for the entire group of the twins, for the 368 both-girl twins, the 246 both-boy twins, and the 210 unlike-sex twins, and the median mental ability with the quartile deviation are shown on Table 1.

TABLE 1

DISTRIBUTION OF PERCENTILE SCORES

Percentile	All twins	Like-sex twins	Boy twins	Girl twins	Unlike-sex twins
90-100	45	30	11	19	15
80-89	76	54	23	31	22
70-79	64	48	19	29	16
60-69	62	43	21	22	19
50-59	86	58	31	27	28
40-49	76	62	22	40	14
30-39	115	90	33	57	25
20-29	94	66	19	47	28
10-19	100	74	31	43	26
0-9	106	89	36	53	17
Total	824	614	246	368	210
Q^3	66.61	65 00	65 95	64 09	70.31
Med	39 73	38.66	41 81	37 19	46 42
Q^1	20 00	18 71	18 22	19 07	23 39
Q	23 30	23 14	23 86	22 51	23 46

That the intelligence of the entire group of twins is considerably below average intelligence is shown by the fact that the median of 39 73 for all twins is over ten points below the normal percentile score of 50, and ten points lower than the percentile score of 50 for the entire group of 119,850 Wisconsin high school pupils who were tested The medians of 38 66 for the like-sex twins and 46 42 for the unlike-sex twins indicate that it is the like-sex twins which pull down the median mental ability for the entire group Since whatever identical twins were in this group would be found among those of like-sex, and since the like-sex group falls so much below the unlike-sex group, the possibility is suggested that the identical twins lower the median intelligence for the whole group, but there are no facts available in this study by which this may be ascertained Among all the groups of twins there is the full percentile range of mental ability, however, but the number of girl twins falling in the upper decile is only about half of what it would be in a normal group, and the number of boys in the upper decile is less than half of the number which would be found in any decile of a normal distribution. The number of boy twins and of girl twins in the lowest decile is far greater than in a normal group, while the number of unlike-sex twins in the lowest decile is somewhat lower than in a normal group

The low ranking of the twins in comparison with the total number of non-twins tested is further shown by the percentage of twins who fall below the twenty-fifth percentile score—where 25 per cent of a normal group would be found Slightly over 30 per cent of all the twins, 32 per cent of the like-sex twins, and 27 per cent of the unlike-sex twins fell below the 25th percentile Likewise, above the 75th percentile score, where 25 per cent of a normal group would fall, are to be found only 18 per cent of all twins, and 16 per cent of the like-sex twins Approximately 25 per cent of the unlike-sex twins have a percentile score above 75, again showing the fact that the unlike-sex twins most closely approach the normal in intelligence rating.

To determine whether the differences between the median psychological test scores of twins and non-twins, and the differences between medians of like-sex and unlike-sex twins were statistically reliable differences, $\frac{\text{Diff.}}{\text{P E}_{diff}}$ was calculated for each pair of medians

That the difference between the median of 50 for non-twins and 39.73 for all twins is a statistically reliable difference is shown by a $\frac{\text{Diff.}}{\text{P.E}_{diff}}$ of 10.37. The other calculations for the reliability of the differences between medians are given in Table 2.

TABLE 2

RELIABILITY OF THE DIFFERENCE BETWEEN THE MEDIANS

Figures shown represent $\frac{\text{Actual diff}}{\text{P E}_{diff}}$

	Girl twins	Boy twins	Like-sex twins	Unlike-sex twins
Boy twins	1.93			
Unlike-sex twins	3.69	1.65	3.33	
Non-twins	8.71	4.31	9.77	1.77

These data presented in Table 2 are given in another form in Table 3, which shows the chances in 100 that a true difference exists between the various medians

TABLE 3

Reliability of the Difference between the Medians
Chances in 100 that there is a true difference

	Girl twins	Boy twins	Like-sex twins	Unlike-sex twins	All twins
Boy twins	91				
Unlike-sex twins	99	87	99		
Non-twins	100	100	100	89	100

From the calculations given in Table 2 and 3, it is evident that the differences between the median mental ability of like-sex twins and non-twins and between all twins and non-twins are completely reliable It is also evident that chances are 99 out of 100 that the difference in median mental ability between like-sex twins and unlike-sex twins is statistically reliable This fact again suggests the question of whether there must not be some factor such as the presence of identical twins among the *like-sex twins which causes this group to fall so much below the unlike-*sex twins in mental ability That the difference between the median *intelligence of non-twins and unlike-sex twins falls to 89 chances out of* 100 of being statistically reliable is another statement of the fact that the *unlike-sex twins more closely approach the average mental ability than* do like-sex twins,

To determine how closely the 412 pairs of twins resemble each other in mental ability the percentile scores of all twins and of each group of twins were correlated In tallying the intelligence percentile scores on the scatter diagram, each pair of twins was tallied twice, the high score being used as the X variable and the low score as the Y variable in the first tally, and the high score as the Y variable and the low score as the X variable in the second tally The coefficients of correlation which were found are given in Table 4

TABLE 4

Resemblance of Twins in Intelligence

	Number	r	PE_r
All twins	824	542	016
Like-sex			
Boys	246	577	.028
Girls	368	.611	022
Unlike-sex	210	441	.037

The coefficients of correlation given in Table 4 show that when twins are compared with each other in mental ability there is a positive relationship in both the like-sex and unlike-sex groups, however, the like-sex twins resemble each other to a greater degree in mental ability than is the case with unlike-sex twins, and the girl twins resemble each other more closely in mental ability than do the boy twins. It is interesting to note that the median intelligence of girl twins is lowest and the coefficient of correlation of intelligence between girl twins is highest, that boy twins have the next lowest median in intelligence scores and when compared to each other, the next highest coefficient of correlation, and that the unlike-sex twins rank highest in median mental ability and resemble each other least. This indicates that for this group of 412 pairs of twins, the twins who are least alike more nearly measure up to normal in mental ability, and the twins who resemble each other most in intelligence fall furthest below normal.

CONCLUSIONS

1. That the median intelligence test percentile score of the 412 pairs of twins found among 119,850 Wisconsin high school students was 10 27 points lower than the normal median percentile score, but that among both the like-sex and the unlike-sex twins the full percentile range in ability was found

2 That the median intelligence test score of like-sex twins fell further below the normal median percentile score than unlike-sex twins, and that the pairs of girl twins fell further below the normal median than the pairs of male twins

3 That the difference between the median of pupils who were not twins and the median of all twins was a statistically reliable difference, that the difference between the median of the like-sex twins and the non-twin pupils was statistically reliable, but that the difference between the median of non-twin pupils and unlike-sex twins was not statistically reliable.

4 That when the relation between the mental ability of each one of the 824 twins with his or her twin was determined by correlation, the girl twins resembled each other most closely, and the unlike-sex twins resembled each other least.

5 That the median mental ability of the twins who resembled each other most closely fall furthest below the normal mental ability, and that the group of twins (unlike-sex) who resembled each other least was the group with a median that most closely approached the normal median.

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REPRESENTATIVE FACTORS IN THE RAT UNDER "CHANGED-INCENTIVE-TECHNIQUE"

IRVING LORGE AND SAUL B SELLS

Tinkelpaugh (4), using monkeys, observed a series of behaviors interpreted as evidence of "representative factors standing for qualitative aspects of the food" The general method of Tinkelpaugh can best be gleaned from his exposition. " . the experimenter displays a piece of banana, lowers the board and places the banana under one of the cups The board is then raised, and working behind it, with his hands hidden from the view of the monkey, *the experimenter takes the banana out and deposits a piece of lettuce in its place* After the delay, the monkey is told to 'come and get the food' She jumps down from the chair, rushes to the proper container and picks it up. She extends her hand to seize the food But her hand drops to the floor without touching it She looks at the lettuce, but (unless very hungry) does not touch it She looks around the cup and behind the board. She stands up and looks under and around her She picks the cup up and examines it thoroughly inside and out After several seconds spent searching, she gives a glance toward the other cup, which she has been taught not to look into, and then walks off to a nearby window "

Elliott (1) as well as Fischel (2) also report anticipation for specific rewards with rats and with goats respectively.

The observations reported in this note are related to the problem of anticipation of reward, or the representativeness of certain acts for specific foods. At the end of an experiment with irrelevant rewards (3), the reward of sunflower seeds was substituted for bread and milk. Three problem boxes were used in the experiment. The animals were given *two trials per day per box, in the order Box A, Box B, Box C for 15* successive days, and in rotated order of boxes for three additional days, In Box *A*, the rat was rewarded with freedom from confinement and with food when it stood up erect on its hind legs ("standup"). In Box *B* *the animal was rewarded similarly when it rubbed its forepaws across* its face ("face-wash") In Box *C* the animal was rewarded similarly when it assumed a crouching position in the center of the box ("beg") These three responses, originally (presumably) irrelevant to food seeking, were learned in the appropriate problem boxes, the time in seconds being reduced from about 500 sec (average) to 2 or 3 sec. (average)

At the conclusion of this experiment, nine rats, B_1, B_2, B_3, B_4, B_5, B_6, B_7, B_8, B_9 were continued in the same procedure for six trials per box (three days), with the exception that sunflower seeds were substituted for the standard incentive of whole wheat bread and milk

The behavior observed in the new situation (sunflower seeds-reward) occurred with every animal. The appropriate responses were made in all three problem boxes The animal, on entering the problem box, immediately made the learned response for that box and started toward the food cup On reaching the food cup, it stopped and sniffed around; then seized a sunflower seed, threw it aside; ran back into the box; made the appropriate learned response again; ran to the food cup again; and continued in this manner (repeating the same performance) until all of the seeds (usually five or six) were thrown away

The sunflower seeds (a food which the animal has eaten on other occasions) brought about behavior that was indicative of the fact that the learned act was a precursor for the specific reward of bread and milk. The behavior of the animal in running back to the problem box and there performing the learned act again is evidence that the learned act in some way represented for the rat the specific food of bread and milk, or that the rat anticipated the specific food of bread and milk.

The modification of technique used in this experiment may throw considerable light upon the nature of incentive, and upon the nature of representative factors in animals Regrettably, motion pictures were not taken of the behavior. A new series of experiments upon this problem is now in progress in which motion picture records of the behavior will be taken.

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SAMPLES OF STUDENTS' ORIGINALITY

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The charge is sometimes made that schools tend to repress the originality of their students. This may be true, but it seems clear that it can be neither proved nor disproved until we have some way to identify the quality in question Information on this point is really needed

I have no idea whether originality exists as a unitary quality, nor, if it does, whether it can be isolated or measured But I thought it would be worth while to gather some specimens of what students themselves can offer as samples of their own originality, so I asked students in elementary psychology classes to write on the subject, under the title "The Most Original Thing I Ever Did." These were the directions.

> Do your best to pick out an example of original activity in your past life. You may not be able to decide which is exactly the most original thing, but choose something which you can recall in a good deal of detail. Let it be something which was really your own, something which you did not copy from anyone else, and which, so far as you know, was truly new to you It does not matter how small a thing it may have been, nor does it matter, for the purpose of this essay, whether it was good or bad.
>
> *Describe as vividly as you can the circumstances which led* up to the event. What was the place and time and occasion of the idea, or the act which you performed? What was the purpose or necessity which it filled, if any? Give especially an account of the preliminary efforts and unsuccessful trials which you made What obstacles did you encounter, and how did you evade or overcome them? Whence came the successful idea? Was it some resurrection of relevant knowledge, or an accident of the environing stimuli? Set down as faithfully as you can *the story of the most original thing you ever did*

No definition of orginality was given except what is implied in the above directions.

From about 900 essays I chose the 10 which are given herewith They were selected not as the best ten but as being typical of the whole range of those written.

A

> The stimulus that aroused me to do the most original thing in my life, was a feeling of sympathy for a little colored girl. I lived in a small, country town where there was but one colored family Little Suzie, ten years old, was just my age and the one colored child She was denied most of the pleasures and treats that other children enjoyed because of the poverty of her parents
>
> One year a lecture course was given in the town and one of the numbers was to be a moving picture. A moving picture was a rare treat and one that the children, especially, anticipated for weeks. On the night of the moving picture my mother handed me a season ticket and, on my request, allowed me to start early I set out for the town hall, in which it was to be held, with a thrill of expectation When I arrived at the door

I saw poor Suzie, longingly—almost tragically lingering on the outside I joyfully showed her my ticket and asked her if she were going She shook her head. She had no ticket. Instantly a feeling of comradeship sprang up between us and we began to discuss the problem

More children gathered on the scene and they joined in on the discussion. We first thought that we might be able to raise enough money with which to buy a ticket. A little boy had two cents and generously offered it. I had a nickel with which to buy candy and I was willing to contribute it But seven cents would not buy a ticket. We then wondered if we dared ask the doorkeeper to let Suzie in for nothing but somehow we felt that it would be useless to ask him We even discussed as to which of us might give our ticket to Suzie. But though we were willing that the other person should give up his ticket, none would make the sacrifice

Suddenly I had a bright idea. I took Suzie around to the side of the hall and carefully instructed her as to the part she was to play Then clutching my ticket, I entered the hall, showed my ticket to the doorkeeper and passed on to the side near a window I cautiously stuck my head out of the window and dropped the ticket into the waiting hands of Suzie Presently she joined me with a beaming face and returned my ticket

That night when I told my mother about what I had done, she tried to give me a talk on honesty. But I felt that I had done a very kind deed in helping Suzie see the moving picture

B

About three years ago I went to West Texas where I lived for over a year and a half on a ranch. As I had practically nothing to do, my aunt suggested that I earn some extra money for myself by raising chickens and selling eggs This idea appealed to me immensely, so I bought three dozen hens and started into business

Within four months I had something over sixty chicks which were doing splendidly and upon which I anticipated making a nice amount of money But I was disappointed in the hens, they did not lay as many eggs as I had expected. In fact, I seldom received more than six or seven eggs a day when I should have been receiving from fifteen to eighteen

I thought about this for a long time and finally I decided the feed had something to do with it So I changed to a well advertised chicken grain mixture which claimed to be a good egg food However, there was no change in the number of eggs laid

The hens then had a well regulated diet with plenty of grass and water, so there apparently was no reason from that source for their not laying And while thinking about this I stood and watched them one afternoon

They seemed perfectly healthy. But as I watched them I noticed that the majority spent all of their time just walking around picking at things or squatting in the dust taking sun baths Only a very few of them scratched in the dirt for scattered grains of seed And suddenly it flashed into my mind that several of those hens who were diligently scratching were ones which I knew positively to be laying It might be that the scratching had something to do with it. And with this in mind I began thinking of ways which would force all of the hens to scratch

The first thing I did was to build a large pen and cover the ground within it with gravel The chickens were then fed within this pen and the food mixed in the gravel so that they were forced to scratch to some extent in order to get it. But the trouble with this method was that they could get all of the grain they wanted without scratching very much Nevertheless, within three weeks the number of eggs received daily had advanced slightly but not as much as I desired However, I knew I was on the right trail, so I tried to think of some way which would make the hens scratch a great deal for a little food

It was very discouraging as I did not seem able to think of anything which would answer the exact purpose. But one night as I was going to bed, I caught my foot in a string which my young brother had tied to a box sitting on the table The jerk of the string opened the flap of the box to which it was tied and several articles dropped to the floor I picked them up and went on to bed without thinking anything more about it. Later, however, I woke up and was unable to go to sleep again While lying there, from force of habit my mind began going over ideas for making chickens scratch and from that it wandered on to the accident which had occurred before I went to bed I remembered what had happened when I stepped on the string and, suddenly without a moment's warning, I thought of exactly the thing I wanted I could see it as plainly as though it were standing before me. It was a long flat covered box with four legs like a table and stood about two and a half feet from the ground Along the bottom on either side were four tiny trap doors which were held on the inside by small springs and could be opened only by a slight pull from without Through a loop on the outside of each door a string was fastened, the other end of which was fastened to a flat lever on the top of a piece of board lying on the ground It was fixed so that whenever a chicken stepped upon the lever the string would tighten and open the trap door enough for a few grains to fall out I knew that when the hens scratched they would step on the levers time and time again But such a tiny amount of grain would fall each time the hens would have to do a great deal of scratching before they had enough food to satisfy them.

Well, as soon as possible the next day, I made this box and put it in the chicken yard. And exactly as I expected, the hens scratched and scratched evidently thinking that the grain was dug up from the ground as it appeared only when they did scratch. In several weeks the number of eggs increased and by the end of a month I was receiving the average of sixteen eggs a day.

Almost a year after I made this box I saw something on the same order advertised in a poultry magazine But that was the first time I knew that anyone beside myself had ever thought of it

C

The following incident may not seem important to my reader, but it was of great importance to me as it saved both mother's and my strength.

Our family consists of six people, and all are very fond of home-made noodles Mother, like most mothers, always tried to please her children and pays much attention to their little whims Rolling dough for noodles, however, is a great task for her, and she is always worn out after she finishes the job. I always help her when I can, but am gone from home so often, and she is left to do the work alone. I have begged mother not to make any more noodles, but she replied, "The boys are so fond of them and I will make the dough softer" It worked out fine as far as the rolling out was concerned, but after cutting the dough the noodles all stuck together I suggested more eggs for the next mess, but this made the dough much too hard and we were both worn out after the rolling process I surely thought mother must finally give up making her noodles, but there was still another way which suggested itself to me within a short time

The week following one unsuccessful attempt at noodle making I took a piano lesson There were some very heavy chords in my solo, but I seemed to be unable to play them loud enough My teacher suggested that I lift my arm higher and *drop down on the keys, as I would have more strength* and force by doing it that way. I tried my chords in that manner, and was able to play them as loud as required without any effort I at once thought of our noodle problem at home, did not say anything to my teacher however

When I came home that day I told mother that our noodle problem was solved, she laughed at me but I decided to try my scheme. I got on top of a chair and in this way had much more strength and was able to roll out the whole mess alone without being the least fatigued Since that time I have discovered that you don't have to climb on a chair, a foot-stool is high enough, and I imagine I would look much better standing on a foot-stool, and rolling noodles on a table, than on a chair.

D

This experience and my consequent invention was not prearranged *at the time of this occurrence* Through *sympathy* and pity my reaction turned out to be the most original thing I ever did

One night as I was working my evening hours in the Union Stage Depot, my attention was drawn to a solitary man This man's condition is almost unbelievable, he is deaf, dumb and blind, and one leg is amputated above the knee. He was an inmate at the County Farm Institution in Downey, California He had come in on the early afternoon stage before I had reported for duty I had been told that he was not only helpless but seemed queer It didn't dawn on me that he couldn't see, as his eyes were very clear though expressionless

After a few hours had passed the man got very restless, and attempted to walk He had the support of a crutch on the side of his disabled limb, but even that did not guide him in the right direction. He crashed into the side wall and I immediately knew *that he needed aid When I reached his* side he held a piece of white paper in his hand I started to talk to him As I touched his arm he put his left hand to *his eyes, then to his ears and mouth, meaning he could not see,* hear, nor speak. Upon reading the note he had written, I found that he was waiting for a certain party who had not received word of his coming He had written the name, address and phone number of his friend, and was begging whoever found the note to phone this party and inform him of his blind friend's presence in town I was unable to reach his friend by phone What was I to do? The poor man must be told that his friend could not be reached. He must be returned to the County Farm How was it to be done? He couldn't see if I did write, nor hear if I talked My third thought was to have some one that could use the mute language of the fingers But what good would this do? He couldn't see Then I remembered hearing about blind people being able to receive communication by rubbing the fingers over raised letters This was my last hope. But how was I to get the sensation through his fingers? I brought him before the glass plate on my desk. Then I placed my hand over his, and using his index finger as a guide, pushed it like a pencil. I formed the letters of each word as accurately as possible, hoping this would convey my message. After about six words a happy smile came over his face, and he nodded his head in answer. He then clasped my hands as a sign of appreciation and a great satisfaction came over me

About an hour later his friend was notified, and upon his arrival I discovered his way of talking. His friend would hold his hand with the palm facing up, and with the other hand made certain taps. When asked by the friend how I learnt his wish, I described my method. He seemed astonished for he had never thought of this means. Upon trying it he obtained better results and conveyed his thoughts without any difficulty, and received prompt answers.

E

When I was thirteen I worked in a Drug Store, and my employer used to let me do what I wished about the place in the way of arranging stock, etc I always wanted to decorate the front window, but never dared to ask the owner for the privilege Finally the chance came It was the week before Thanksgiving and the Druggist was going away over the holiday When he left he told me that I was in entire charge of the store, and providing I refrained from mixing any fatal prescriptions, I was at liberty to do as I pleased. Well, here was my chance Such an opportunity as Thanksgiving should not be overlooked by a good window trimmer. So I went to work, somewhat timidly At this stage I would bring in a little psychology There was the window, empty. Behind me was a store full of pill boxes and bottles The occasion, Thanksgiving, seemed to offer excellent opportunities. Beyond that I had no inspiration But the occasion brought the idea to me Clearly it must be decorated in Thanksgiving dress. I brought a cart load of autumn leaves down from home, and while I was thus busied the rest of the idea formed I carted a huge pumpkin down, and placed it in one side of the window, with a laboriously printed card inscribed "YESTERDAY." Then I persuaded my mother to bake a large pumpkin pie for the cause This, with a plate of cheese, I placed in the center and labelled with a card bearing the word "TODAY" Then I finished the window by putting on the other side, under the caption of "TOMORROW," an artistically arranged pile of pill boxes, all bearing labels relating to stomach troubles

No inventor ever watched his work with prouder eyes Every time the display drew a smile I thrilled with pride But that is off the subject I believe that every original work is the result of some definite need The inventor feels that need At first he may only see a part of the solution, and my illustration was meant to bring that out, but one step leads to another, and after he has worked with it a little while the whole answer comes as in a vision.

That's what originality is,—the ability to see things before they are created.

F

In thinking back over my experiences I have discovered what an unoriginal person I am I seem never to have done anything original enough to merit being written about However, since necessity demands it, I am going to tell how I managed to save time in the making of a drooping brim buckram hat frame One of the requirements in millinery work, especially in the foundation work, is speed I was working in a store in a town where there were no wholesale houses, and when we occasionally ran out of certain frames it would fall to my lot to make them out of buckram My employer was a good business woman, and an excellent saleslady, and a splendid judge of good work, but she was not a millinery maker The trimmer had gone on her summer vacation, that being the dull season It was at this time I had my first buckram frame to make, and it was a plain drooping brim. I had seen trimmers copy hats by making paper patterns. They would take the hat to be copied and fit tissue paper over it with pins, and cut the pattern while pinned to the shape So I thought that would be my best method of procedure I had always wished to try my hand at pattern making—it looked so simple So I went through an elaborate process of pinning and fitting the paper on the under side of a straw hat of the correct shape My work resulted in a drooping brim of rather uncertain droop and a badly shaped headsize which had to be worked with for some time in order to give it the right shape When finished it was not a bad frame, but the time consumed in making it was too long I knew I must find a quicker way to make a plain frame—quicker and with less work Next time I tried taking a flat brim and by splitting it in four places and lapping the slits I knew I could make it droop But when the hat was covered with silk each of the "humps" made by overlapping showed through the silk Then I had to go to the extra work of padding the frame to hide the slits So I tried to figure another way to meet this simple, tho troublesome problem At a soda fountain another idea presented itself. The cone shaped paper dishes in which they serve ice cream gave me a new light on the question and I decided that I could make the frame with a good droop and have just one slit in it. I took a flat section of buckram Part of the problem now facing me was to get my circle for my frame and get the oval headsize in the right place in the circle. This, however, I had learned before So I took a crown and with a pencil I drew the outline of the bottom circle and got my oval for the headsize and by measuring out from this oval in all directions at points rather close together I could draw the outer circle This gave me a flat sailor By splitting this from the headsize to the edge and lapping over as the cone had been I got a good dropped brim—but when I lapped it, the headsize was made smaller, and when I had enlarged it, I had a brim which was too small A few days later I was working on a manufactured drooping brim It had been necessary for me to slit this brim in the back and insert a piece of buckram in order to enlarge the headsize and at the same time keep the width of the brim the correct size. When it was slit and lying on the table I accidentally put my hand on it, and in doing so I pressed it flat on the table. The shape which the frame was then thrown into—perfectly flat with a cleft where I had made the slit showed me the solution of the problem, for there was my pattern with the correct headsize, the correct proportions for every part. I pressed the frame flat on a piece of paper and made my paper pattern from it From this time the making of a drooping frame was the simplest matter, for I kept the pattern thus made, always on hand

G

It was early in the spring of 1917, on a farm in Central Iowa, where this incident occurred It was a perfect spring morning and washday My mother had a power washer which was operated by a gasoline engine As my father was rushed by his spring work, I was kept home to keep the engine running Although I was only about twelve years of age, I had managed to take the engine apart in time of need and reassemble it so it would run.

The washing had progressed nicely for about an hour when the engine stopped. I immediately attempted to repeat my past performances, but to no avail. In the meantime my mother became impatient and I was drafted in to service to operate the machine by hand, but this was not a very enjoyable occupation especially on a perfect spring morning It was after nine A. M and I knew I would not have to go to school if I did get the engine to run, so it was decidedly to my advantage to get power to operate the engine If I could do this I would have the rest of the afternoon to myself

While operating the machine I did some deep thinking I finally thought of the auto in the garage and how I could use it in operating the washing machine I told my mother of my plan but she was more interested in getting the washing completed than of my getting out of operating the washer by hand While she was preparing the second tub of clothes, I ran the auto out and placed it in line with the washer. The washer was in a building so I had to tear a board off the building to run the belt through. I located the auto so the belt would reach and then I jacked up the rear wheels and put on the belt I then started the motor with it in high gear The result was that the opposite wheel from the one I had the belt on would run and the one with the belt on would not run I then let the opposite wheel on the ground and tried it again I had overcome that obstacle but the large wheel on the auto and the small wheel on the washer made the ratio so great that with the motor running slow the washing machine ran altogether too fast

My mother had been waiting on me a while and when I failed my second attempt she would give me no more opportunities so I had to wash a second machine full of clothes by hand Before I had completed washing the second tub of clothes I thought of putting the belt on the hub instead of the wheel. By this method I reduced the ratio to such an extent that when the motor was running slow the machine would hardly run With this method I could operate it at any speed I desired by regulating the speed of the motor. As the result of this accomplishment I had the rest of the forenoon to myself and reduced my dread of washing because my possibilities of operating the washing machine by hand was reduced to one-half of what they were before my discovery.

H

In the summer of 1915, my parents bought a cabin in the Santa Anita Canyon This cabin, they bought from my uncle, *which he built in 1911. He was not a carpenter or stone*-mason by trade, so he built his cabin largely to his own specifications and ideas, as did the majority of the other cabin owners in the canyon

The cabin was made of stone and wood, and had a cement floor. There was only one large room, with a fireplace in one end, and a cookstove in the other The fireplace was made entirely of stone, and was about three and one-half feet high, by about two and one-half feet wide; slightly arched at the top, and was made flush with the floor, as were the fireplaces in all the other cabins that I had observed.

For some reason or other, ever since the cabin was built, the fireplace wouldn't draw properly It had a good "throat" in it, and there were no holes or cracks in the chimney by which air might enter, but nevertheless it would not draw My uncle complained of the same fault, and I remember that the fireplace would often smoke so badly that it would be almost impossible for anyone to remain in the room with a large fire burning It seemed as though more smoke came out into the room than went out of the chimney.

Many guests that we often had with us from time to time also witnessed the discomfort, but none were able to offer a method of correcting the trouble, none knew why it should act like this, as in every way, the fireplace was apparently constructed essentially on the same lines as other fireplaces

We tolerated the smoke for about three years, until finally I became so disgusted, that I was determined to locate the trouble. So one day I built a small fire in the fireplace and closed the door, and all the windows, so that any breeze would not effect my experiment I then seated myself in front of the fire to watch the action of the smoke

I noticed that even when the fire was built a considerable distance from the back wall of the chimney, the smoke would quickly move back, go straight upward parallel with the wall for about two and one-half feet, and then about half of the smoke would come directly out into the room, the rest going out through the chimney

I watched this for several minutes without drawing any conclusions, and finally, seeing that the smoke always went straight up, before coming out, I hit upon the idea of shortening the opening of the fireplace, so as to make the arch come down a little below the point where the smoke turned away from its perpendicular path. But how was I to do this? I couldn't pull the arch down The only way I could shorten the opening was to build it up from the bottom I immediately proceeded to do this, and with rocks and cement, built the floor of the fireplace up about a foot The opening of the fireplace was then practically square, being about two and one-half feet on a side. When I again built a fire in it to test it out, I found that it drew perfectly; all the smoke going out the chimney as it should.

I

During my fourth year in high school I was in the biggest play of the year Because it was the biggest play to be presented that year every one in the cast felt that it must be put over bigger than any other one so far

One day while practicing on the third act which was supposed to be out on a deserted island the teacher called the cast together and said "I don't know what we are going to do for a device that will give the effect of the ocean off in the distance It will not be seen on the stage and will be merely for effect. But this is the idea. As night falls out here on this lonely island and everything becomes quiet Crichton (a butler) is sitting alone, smoking his pipe by a fire and over the fire hangs a huge kettle. The fire gives the only light on the stage and the only sound is the quiet rustling of bamboo and the breaking of the ocean waves Now this is the conclusion I have finally come to. Each one of you between now and Monday try and find some way to make a breaker effect"

The next day I happened to be standing near a place where a cement drive was being laid I was talking to a girl and was quite unaware of my surroundings I suddenly realized that there was a swishing suond of breakers being made some where nearby. As I turned to see what it was I saw a man throwing sand on a wire screen and as the first sand went down it made a sudden swish—resembling the breaking of the waves There was an idea The next thing was to work it out so it could be used on the stage because we couldn't have some one shovelling sand on the stage hardly. So I spent the next day planning.

When Monday morning came this was my plan Have a large tray with a piece of tin on the bottom and boards about six inches deep on all four sides. Put some, not much medium coarse sand in it and then tack a piece of screen over the top of this tray. Now balance this tray on a saw horse but do not nail it. Leave it free to move up and down. To use it take hold of one end up slowly and gradually faster. Then finally let the rest of the sand go down at once After a few seconds tip the other end up in the same manner as the first one. The slipping of this coarse sand over the tin gave a perfect resemblance of the sound of ocean breakers This device was used and after the play several people wanted to know how the ocean effect was made. Among these people was a man from one of the big theaters here in Los Angeles The teacher at the head of the dramatic department told me a few days ago that this man has used this device a few times since and it has been very successful.

J

A few years ago I lived in a very small village in one of our most Northerly states It was one of those jerkwater towns that have one lawyer, one drug store and no traffic cops. I lived alone with my mother, a semi-invalid, for whom I had the utmost pity and sympathy, although never totally comprehending the nature of her malady

A friend of mother's, a young surgeon who had just completed his studies was staying with us for a short visit At about this time my mother seemed to be getting weaker and more nervous. Everything irritated her and she must have been in constant pain. Late one afternoon I was returning home with our guest from an extended tour of the surrounding hills, and entering the house, beheld my mother lying on the

> floor and holding her abdomen in the direst agony. She could hardly speak. I was terrified and begged the physician to do something for her After a swift examination he said, "Only an immediate operation can save her."
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> The only doctor lived two miles out of town. Knowing it would be impossible for him to arrive in less than a half hour, I asked our guest if he would perform the operation He hesitated a moment, but my mother's agony was so intense that he consented, ordering me to procure the surgical instruments case from his room
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> He laid my mother on the dining room table, which had been covered with a clean sheet, and selected his instruments I stood near eager to help, watching his every move Just as he was ready to make the incision he examined closely one of the smaller instruments he had laid out on the table With an air of finality he exclaimed, "I can't go on with the operation This gold instrument is nearly black from tarnish and disuse If used it might cause blood poisoning, and I must use it"
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> Despair overwhelmed me momentarily. Then I pulled myself together with determination, telling myself that I HAD to think how to clean it I knew water or the ordinary cleansers would not suffice I held my head in an effort to create a way or a means Here was my mother dying beside me and both of us powerless to aid her At that moment I believe I experienced pure and perfect concentration, for then the idea came
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> I was then wearing braces on my teeth, heavy gold ones that blackened very easily and often from the acid and food passing into the mouth These I could make bright and shining by giving them a good brushing with a strong brand of tooth paste I had Why wouldn't that clean any article of gold? I dashed after the tooth paste and brushed it vigorously on the sharply tapered piece of gold Success gladdened my heart for the blackness disappeared at once The instrument was clean and shining The surgeon proceeded with the operation which was highly successful Thanks to the intense thinking stimulated by the fear of losing my best friend, my mother, the operation which made it possible for her to be with me today was able to be performed

In order to see how well people would agree in judging these samples I had them printed and distributed to students in advanced classes in *psychology They were asked to rate the essays in order of merit for* originality Averaging the ratings of 391 persons gives the following order, from best, 1, to worst, 10.

1. *B*. The Chicken Box
2. *I* The School Play.
3. *D*. The Blind Deaf Dumb Man
4. *G*. The Washing Machine.
5. *H* The Cabin Fire-Place
6. *J* The Operation.
7. *E* The Drugstore Window
8. *F*. The Hat Frame.
9. *C*. The Noodles.
10. *A* The Theatre Ticket.

The reliability of this order is high. The two sections of the class correlated to the extent of 95 It is obvious, however, that there are other variables, aside from originality, present in this list of episodes For example, *B* differs from *A* in the complexity of the action as well as in the ethical aspect of the case and in the literary forms of its presentation. These things may affect the rating for originality. But then, it may be legitimate that they should, in case "originality" turns out to be a vague honorific term for anything singular.

As to the question, *What is originality?*, the only contribution which this paper has to offer is that the term, as used by college students in our group refers to something which increases as we go up our list from *A* to *B*. I think the value of the essays lies in the fact that they give *illustrations of thinking processes in somewhat fresh and concrete settings*

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INFLUENCE OF INCENTIVES UPON INTELLIGENCE TEST SCORES OF SCHOOL CHILDREN

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It has been shown that motivational factors may affect the efficiency of performance in a variety of intellectual tasks (1, 2, 3, 5). The question of whether such motivational factors affect the efficiency of performance in group intelligence tests has obvious significance for the theory and practice of group intelligence testing. It will be recalled that Terman, in the general instructions for the administration of the Stanford-Binet, emphasizes the necessity of securing the maximum degree of attention and effort in the child being tested and that he mentions praise and encouragement as potent factors for keeping the child at his best level of effort (7, pp. 121-125) If it were to be shown that motivational factors do have an appreciable effect upon the efficiency of performance in group intelligence tests, it would indicate that such factors must be controlled if the test scores are to be considered valid indices of the intelligence of the children tested

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[1] This investigation was carried out at the Brewster High School, Brewster, N Y. The author is deeply indebted to Mr. H H Donley, Supervising Principal of the Brewster High School for his cooperation during the course of the investigation.

Two studies bearing directly upon this question have been reported Hurlock (4) has reported that either praise-encouragement or reproof as motivational factors were more effective in raising the scores of elementary school children than was mere repetition of the test The National Intelligence Test, Scale *B*, Form 1 for initial test and Form 2 for retest, was used for the 5th and 8th grade children. The Otis Intelligence Scale, Primary Examination, Forms *A* and *B*, were used for the 3rd grade children. However, Maller and Zubin (6), employing the National Intelligence Test, Scale *B*, but using Form 1 for both initial test and retest, found that no greater gain in score was achieved by children who had been motivated by the promise of a prize if they bettered their relative standings on the second test than by children who were merely given the test again Each child in the "incentive group" was informed of his relative standing on the test and was promised a prize if he bettered his rank on the second test.

In view of the contradictory character of the results of these two experiments, an attempt has been made in the present experiment to attack this problem again The motivational factor has been made as strong as possible and this factor includes praise, strong encouragement, knowledge of results and the promise of a prize

METHOD

The Otis Self-Administering Test, Intermediate Examination, Form *A* was given to a group of children in the 7th and 8th grades Two groups of 25 children each were formed Each child in one group was matched with a child in the other group with respect to age, score on test, sex and grade[2]

There were 12 boys and 13 girls in each group. The mean age of each group was 13 years, 5 months and the mean scores of the groups were 50 0 and 49 8 After an interval of 28 days, the test was again administered

---

[2] Two children were considered to be matched with respect to age if their ages did not differ by more than seven months and to be matched with respect to score on test if the scores did not differ by more than four points.

To one of the groups, the control group, the test was again administered just as in the initial test The children of the other group, the "incentive" group, were told by the author what their relative standings on the test had been and they were promised a prize if they bettered their relative standings on the second test. In addition to this, the school principal addressed them, praising them for their good work and strongly urging them to do better on the second test The exhortation was made as strong as possible.

RESULTS

The control group made a mean score of 50 0 on the first test and a mean score of 55.7 on the retest. Thus the control group made a mean gain in score of 5 7 points *from initial test to retest The incentive group made* a mean score of 49.8 on the first test and a mean score of 54 6 on the second test. Thus the incentive group made a mean gain in score of 4.8 points from initial test to retest. It will be seen at once that the difference in the gains of the two groups is extremely small(9) and that it is in favor of the control group This difference is statistically unreliable ($\frac{\text{Diff}}{\sigma_{diff}} = 9$). It may be concluded that there is no significant difference in the gains of the two groups

Variability of Scores Maller and Zubin found in their investigation that variability in score increased upon retest under incentive conditions while it remained virtually the same under control conditions. The data of the present experiment have been examined with respect to this point. For the control group, the S.D of the distribution in the initial test was 10.4 and the coefficient of variation was 20.8 In the retest, the S.D. of the distribution was 10 0 and the coefficient of variation was 17.8 For the incentive group, the S.D of the distribution in the initial test was 9 9 and the coefficient of variation was 19 9. In the retest, the S D of the distribution was 9 6 and the coefficient of variation was 17.5. There was a small decrease in the variability of the scores of both groups from initial test to retest.

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THE RÔLE OF SENSORY ACUITY IN LEARNING AND SENSORY DISCRIMINATIONS[1]

EDWIN E. GHISELLI AND FRANKLIN M. HENRY

Although there has been considerable interest regarding the rôle of sensory cues in learning, apparently the relation between the formation of a sensory discrimination habit and the acuity of the corresponding sense has not been investigated. In connection with other studies the writers have secured data which can be used to throw some light on this question These data consist of learning scores and thresholds for a group of 32 rats on a problem involving proprioceptive discrimination (1), and another group of 22 rats on an auditory discrimination problem (2, 3)

The proprioceptive problem involved the discrimination between a runway inclined at 20° from the horizontal, and another with zero inclination After this problem had been mastered the inclination of the second runway was increased step by step until the angular difference between it and the first was only 1° This permitted the determination of the differential angular threshold In the auditory problem the animals were required to discriminate between a tubular alley filled with a 4000 cycle pure tone, and a similar alley that was relatively silent. At the choice point the difference in intensity of sound in the two alleys was 16 decibels After the initial learning the tonal intensity in the more silent alley was increased by suitable amounts until it approached within 3 decibels of the other alley This made possible the measurement of the differential intensity threshold. The animals were then presented with the original problem, and the tonal intensity was reduced by successive 5 decibel steps giving a measure of the absolute threshold.

Following the usual practice, the threshold for each animal was calculated in terms of the stimulus value that would have resulted in its discriminating with 75 per cent accuracy. In computing the learning scores a criterion of 75 per cent accuracy was also used However, all animals achieved 90 per cent accuracy in the original learning before the threshold determinations were begun.

In the proprioceptive problem, a product-moment correlation of .31, with a probable error of .11, was obtained between the differential sensory threshold and the number of trials required to reach the criterion of learning In the case of the corresponding auditory discrimination the correlation was found to be .36 ± .13. For the absolute auditory threshold a correlation of .21 ± .12 was obtained.

It is seen that there is a low positive relationship between the stimulus

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[1] This analysis evolved from a conversation with Professor E. C Tolman concerning the relationship between learning and sensory acuity

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It is seen that there is a low positive relationship between the stimulus intensity required for a given accuracy of sensory discrimination, and the amount of practice required to reach this accuracy in the original learning of the discrimination It should be noted that in every case the stimulus intensity in the original learning situation was well above the highest individual threshold For the inclined plane discrimination, the highest difference threshold was 7 5°, while the angular difference presented during learning was 20°. In the auditory discrimination the highest difference threshold was 9 8 decibels, while during learning a difference of 16 decibels were presented The highest absolute auditory threshold was at least 10 decibels below the intensity used during learning

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[1] This analysis evolved from a conversation with Professor E. C Tolman concerning the relationship between learning and sensory acuity

It is quite possible that a different magnitude of relationship would have been found had other stimulus intensities or sense modalities been used. However, in view of the fact that the two discrimination situations that were investigated involved widely different sense modalities, it seems warranted to conclude that for discrimination problems using stimuli well above threshold, a low positive relation exists between sensory acuity and learning efficiency

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BOOKS

N. R F MAIER & T. C SCHNEIRLA *Principles of Animal Psychology* New York. McGraw-Hill, 1935. Pp. xiii+529

The object of writing this book, according to the authors, has been to produce a systematic textbook which will serve the purposes of college courses in biology and psychology.

The book is divided into three parts Part I presents experiments and theoretical views bearing upon the behavior of infra-mammalian forms, with reference to a cross-sectional classification of this material

Parts II and III, which constitute approximately one-half the total presentation, deal exclusively with questions of mammalian behavior, an emphasis being laid upon the topic of learning. The second part, titled as a discussion of the "Prerequisites of behavior dominated by modifiability," presents material concerning inherited activities, discriminatory reactions, and the relation of certain structures and functions of the nervous system to learning and discrimination Part III, in addition to describing in the last chapter certain kinds of "higher mental processes" in mammals, centers around the typical subjects of conditioned response, discrimination habits, problem solving, maze response, drive, and the factors influencing the rate of learning Integration of the material throughout is secured by keeping the topic of modifiability of behavior in the foreground

Maier and Schneirla maintain consistently a mechanistic point of view *throughout their work, that is, an attempt is made to describe changes in* behavior in a scientific way by reference to known facts regarding the structure and functions of the response mechanism It may be said that the entire presentation successfully avoids common fallacies of explanation and description in terms of phenomena which themselves are unknown and incapable of being scientifically examined

The discussion of learning and modifiability in behavior takes up by far the larger part of the book, and other problems are, in general, subordinated to a consideration of this topic. Learning is said to exist either in primitive or more complex form throughout the phyletic series, but no concrete definition of this phenomena is presented until the nature of learning in mammals is considered. In connection with the treatment of certain facts regarding the conditioned response, learning is alleged to consist in "the ability to combine (or associate) two or more contiguous experiences in cases in which the contiguity is determined by the environment." Problem solving, maze learning, discriminative learning, and so forth, differ from the conditioned response in that the reaction of the animal is not under the control of the experimenter. The delayed reaction, rapid learning, instances of abstraction, and multiple choice are considered as not being indicative of higher mental processes or ideational behavior, but certain situations involving complex maze responses and the handling of sticks and boxes are held to necessitate "reasoning" or the "re-organization of experience" for their solution. Evidence is cited to prove that this ability depends upon an intact cerebral cortex.

The reviewer's criticism of the work of Maier and Schneirla involves the following main points. Fundamental concepts of "stimulus," "response," "behavior," "adaptation," "integration," "learning," etc, are not clearly defined, and the definition of these phenomena, when given, does not arise out of a broad consideration of the experimental techniques and observations on the basis of which they have been elucidated. This defect of a definitive approach to the problems discussed serves to obscure, through the greater part of the book, the essential points which the writers desire to make concerning phylogenetic changes in functional capacity The work is notably lacking in regard to the consideration of facts concerning the phylogenetic development of the receptors and phylogenetic differences in sensory capacity, although the concept of sensory control is utilized consistently throughout all parts of the book For example, the discussion of sensory discrimination in mammals is confined almost entirely to vision and audition, and there are similar lacunae in the treatment of the behavior of lower forms No attempt is made to explain or to develop ideas regarding behavioral criteria, on the basis of which phylogenetic differences in behavior may be qualitatively compared Nowhere in the book is the concept of threshold explained, nor is the relation between the idea of threshold and that of functional capacity at any time elaborated. In addition, the treatment of the relation between neural processes and behavior is incomplete because of the failure to present a systematic treatment of the development of the nervous system and its functional properties, especially in regard to such developments in higher forms The chapter describing the relations between neural mechanisms and behavior in these animals is confined almost entirely to the citation of investigations on the rat.

The treatment of the main theme of the book, the topic of learning, is weakened by failure to establish a clear-cut picture as to the objective nature of this change in terms of stimulus and response, by an insufficient report of the quantitative material bearing upon this subject in relation to mammalian behavior, and by an inadequate consideration of the diversity of views, many contrary to opinions of the authors, which exist in this field at the present time Much of the value of the last and longest chapter of the book is lost to the reviewer because the main point of the writers here appears to be that there is a process of reasoning in animals, somehow independent of learning, which has been demonstrated only in the rat's performance on certain complex mazes and in the chimpanzees, studied by foreign investigators, which proved to be able to stack boxes and manipulate other objects. It seems to the reviewer that these particular experiments, rather than indicating a capacity for response existing independently of the changes in behavior due to learning and growth, show very clearly how a situation, essentially familiar in various details to an animal, can be rearranged arbitrarily so as not to interfere with reactions learned under those same general conditions in the past.

In spite of the criticisms just mentioned certain reasons may be given why the "Principles of Comparative Psychology" can be considered as a desirable addition to the present literature in that field. No other work is available at this time which covers the entire field of animal behavior with regard to an emphasis upon learning. In the book, the work of prior investigators is, in general, accurately described and, according to the avowed purposes of the text, is classified in a very satisfactory manner Furthermore, the writers are to be commended for their attempt to apply some of our present knowledge of the response mechanism to the description of the antecedents of certain complex aspects of behavior and at the same time avoid pseudo-explanations and speculative accounts The reviewer would recommend the book for the original views which it expresses regarding learning and modifiability in arthropods and concerning the nature of complex forms of adaptation in mammals.

Three to six selected reading references are given at the end of each chapter, together with a general bibliography of six hundrd fifty-eight titles at the end of the book

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